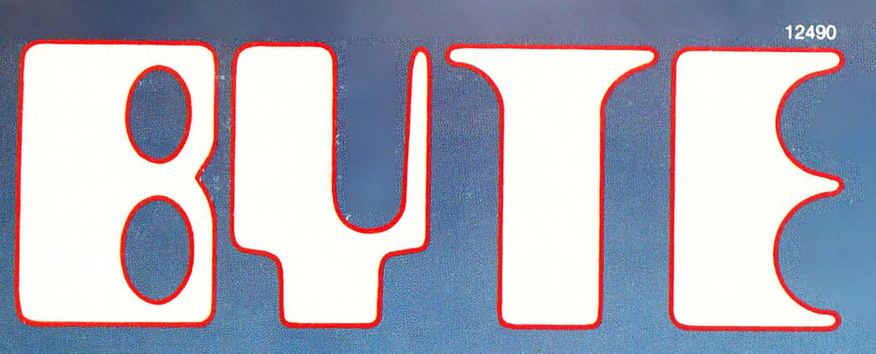


12490 ®

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the small systems journal

BENCHMARKS

APPLE'S MACINTOSH

Inside Apple

Vol. 1, No. 4

A dot matrix printer that will improve your image.

Meet the Apple® Imagewriter, the newest dot matrix printer for your Apple Personal Computer.

And with all that it has going for it, just maybe the best dot matrix printer on the market.

Take legibility, for instance.

The Imagewriter crams 140 x 160 dots into each square inch. So you get text that's highly readable and high resolution graphics, besides.

And is it fast.

The Imagewriter cruises at an unbelievable 120 characters per second. And that's just in the text mode. It's even faster printing graphics. 180 characters per second, to be exact.

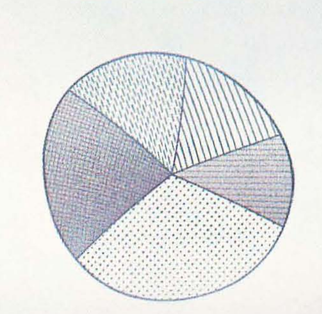
What's more, the graphics dump is up to 60% faster than other comparably priced dot matrix printers. And that makes the Imagewriter fast enough to handle the Lisa.™

Yet it's just as at home with an Apple III or Apple IIe. Thanks to Apple software experts who designed the control electronics to give the Imagewriter perfect compatibility. Not to mention some special capabilities like superscript and subscript, to name just two.

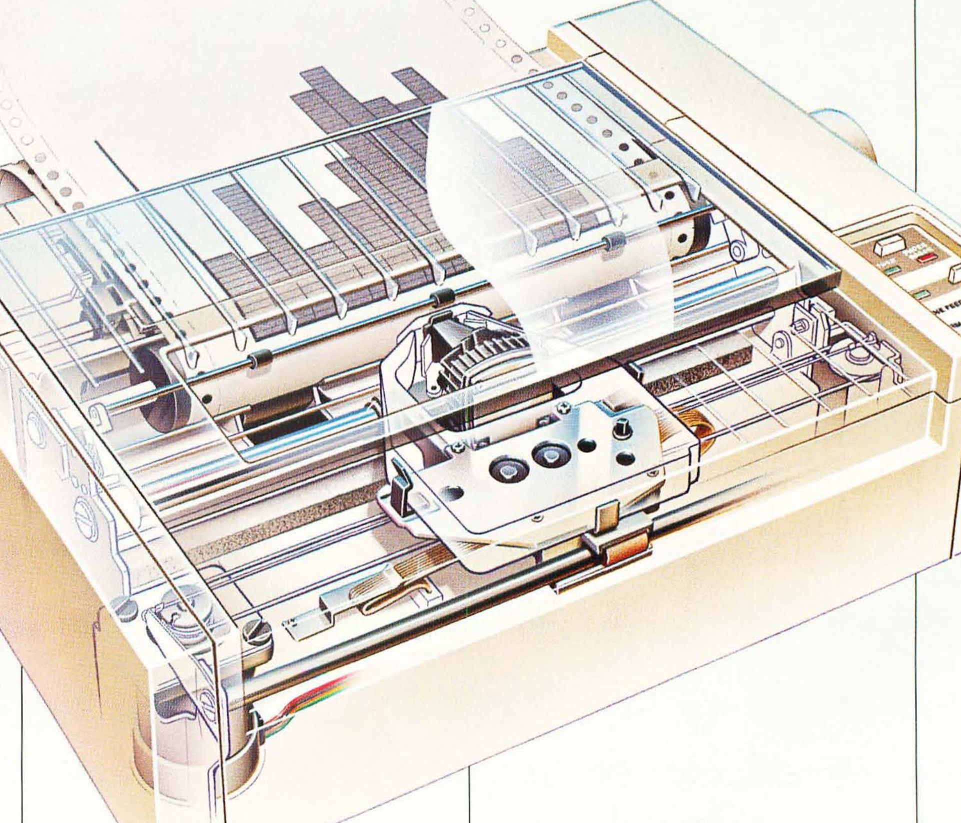
Now, with all this high-speed performance, you'd expect the Imagewriter to make the Devil's Own Noise. It doesn't. In fact, the Imagewriter is specially constructed — with overlaid seams and special sound-deadening materials — to achieve a remarkable 53 dB. How loud is a remarkable 53 dB? You'd make more noise if you read this aloud.

The Imagewriter even has quiet good looks, since we designed it to look like the rest of the Apple Family.

Yet even with all its improvements, the Imagewriter is a better deal than any other dot matrix printer with comparable performance. And you can print that.



APPLE PRESENTS TH
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In The Queue

BYTE Volume 9, Number 2



Page 30



Page 58

Cover Story

Columns

Themes

Reviews

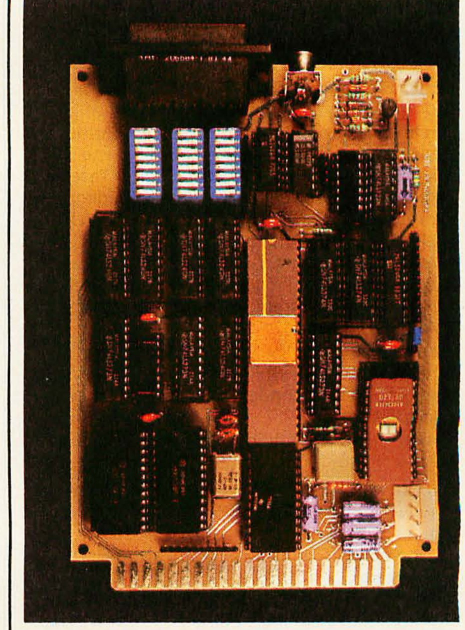
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Nucleus

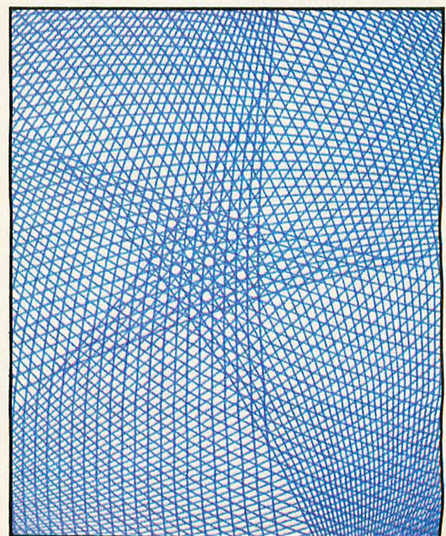
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Page 88



Page 278



Page 388

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Editorial

The Compatibility Craze

American history is dotted with inventors—from Thomas Edison to the Wright Brothers—who could not have succeeded without substantial innovation. Indeed, the Wrights had to discard most of the recorded experience of others who had gone before them in nonpowered flight; they truly had to pioneer in propulsion, aerodynamics, and aircraft piloting.

Drs. Shockley, Brattain, and Bardeen revolutionized the world of electronics with their invention of the transistor 36 years ago—an invention that spawned an era of innovative solid-state design in a range of products from radios to computers. But the world of personal computers doesn't appear to be characterized by innovation today. Instead, the personal computer market seems to be shadowed under a cloud of compatibility: the drive to be compatible with the IBM Personal Computer family has assumed near-fetish proportions.

The compatibility craze was evident everywhere at the recent Comdex show in Las Vegas. Billboards outside the convention center and booth personnel inside proclaimed how closely the company's products imitated the IBM PC family. That kind of imitation is inevitable in the light of the phenomenal market acceptance of the IBM PC.

We devoted the theme section of last November's issue to the IBM PC and its clones because a growing fraction of our readers own or use such machines. Unavoidably, we took some heat from some of our more vocal readers who regret IBM's strong emergence in the PC market. Some of those readers sounded a concern with which we heartily agree: that IBM's burgeoning influence in the PC community is stifling innovation because so many other companies are simply mimicking Big Blue.

Innovation usually prospers in companies that respect the role of research and development and which fund R & D appropriately. Most large companies recognize that R & D eventually leads to innovative products that will enhance revenues and profits, but large companies also have a built-in inertia that militates against the risk-taking associated with unproven new products.

Few companies are in a stronger position to foster innovation than is IBM, which has long recognized and generously sponsored R & D. We urge the company, therefore, to encourage the migration downward to its personal computer families of innovative developments that often find their first practical application in larger computers. Such developments could soon include flat-screen displays, half-megabit RAMs, and office-by-example (OBE) software.

We also urge venture-capital organizations to include innovativeness in their checklist of attributes when they are approached by those with ideas who need financial backing. Often the people with such ideas have run into the no-risk inertia of a large corporation, become frustrated with that environment, and have founded successful new companies with the help of backers who are willing to take risks.

We believe innovation has kept U. S. industry competitive in world markets until the recent emergence of keen foreign competition in such basic industries as steel and autos. And we believe it will be innovation that keeps the U. S. knowledge-based industry competitive in the years to come.

—Lawrence J. Curran, Editor in Chief

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Cromemco offers you the most complete line of S-100 boards and peripherals in the business. These boards use the new IEEE-696 state-of-the-art standard. One-stop shopping can satisfy your design needs the easy way.

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MICROBYTES

Staff-written highlights of late developments in the microcomputer industry.

COMMODORE PLANS UNIX-LIKE OPERATING SYSTEM FOR Z8000-BASED COMPUTER

Commodore announced that it will include the UNIX-like Coherent operating system in a new series of Z8000-based computers. Scheduled to be formally announced in May, Commodore's new computer will be called the Next Generation and will include 256K bytes of RAM and one or two floppy-disk drives at a price the company says will be much lower than any comparable system.

All of Commodore's previous computers have been based on variations of the 6502 microprocessor developed by Commodore's MOS Technology division. Commodore has a license to manufacture Zilog's Z8000 processor.

BOOST IN IBM PRODUCTION COULD SPELL PROBLEMS FOR CLONE MAKERS

In a December speech, IBM senior vice-president Allen Krowe told security analysts that production of the IBM PC will increase as much in 1984 as it did in 1983. Such a dramatic increase in production of the PC could create problems for smaller computer companies using the same parts.

Intel Corp., maker of the 8088 central processor used in the IBM PC and most PC-compatibles, doesn't expect any major problems with that part, although both Intel and Advanced Micro Devices are pushing back their delivery schedules for companies ordering the 8088 and 8086. Intel was less positive about production of the 8088-compatible 80186 processor, which runs faster than the 8088 and eliminates the need for several peripheral chips. Many computer makers have chosen to use the 80186 because of its speed and economy, but Intel expects to ship only about a million 80186 chips this year, although it predicts that demand will be between 3 and 4 million.

Advanced Micro Devices, which has a technology exchange agreement with Intel, will also produce the 80186 later this year. The company would not predict how many it will ship, though it plans to double production of the 8088.

DIGITAL RESEARCH, ZILOG, AMI AGREE TO PUT PERSONAL CP/M ROM ON Z80 CHIP

Digital Research's ROM-based Personal CP/M operating system will be included on some versions of Zilog's Z80 microprocessor, according to an agreement between those two companies and American Microsystems Inc., which will be the first to make and sell the chip. Although no pricing has been announced yet, bundling Personal CP/M on a Z80 chip will probably result in less expensive home computers. Digital Research plans to collect a smaller royalty for CP/M on each chip than it would otherwise charge, in consideration of the large number it expects will be sold.

SEAGATE AND VERTEX UNVEIL 100-MEGABYTE HARD DISKS

Seagate Technology introduced its first 8-inch Winchester disk drive, with 102.1 megabytes of storage. Previously, Seagate made only 5¼-inch Winchester drives, dominating that product market. In large quantities, the company's 8-inch drives will cost less than $1500 without a controller.

Vertex Peripherals announced a 100-megabyte 5¼-inch Winchester disk drive that will sell to manufacturers for about $1700 in large quantities. Vertex, which also makes 30-, 50-, and 70-megabyte 5¼-inch Winchesters, plans to announce higher capacity 5¼-inch drives this year.

INTEL INTRODUCES 64K-BYTE CMOS RAMS

Intel is beginning full production of 64K-byte CMOS dynamic RAM chips this month. Because the chips require less power than conventional memory devices, they will probably be used first in battery-powered portable computers. Intel expects to produce the chips in very large quantities at prices only slightly higher than conventional NMOS dynamic RAMs.

KEY TRONIC LICENSES NEW MOUSE TECHNOLOGY

Key Tronic Corp. has licensed the solid-state mouse technology developed by Display Interface Technology. Key Tronic had previously been considering use of the Summagraphics optical mouse but now says the solid-state mouse is superior. The company will sell two versions of the mouse to both manufacturers and end users: an RS-232C version will retail for $226, and a version to add to some Key Tronic keyboards will sell for $184, beginning in April.

THE MARKETPLACE IS FLOODED WITH NEW PORTABLE COMPUTERS . . .

Several new portable and transportable computers have been introduced recently. **Visual Technologies** unveiled the Commuter, which includes a single 5¼-inch disk drive, 128K bytes of RAM, and MS-DOS 2.1 for $1995. . . . **ACT** has brought its British-made Apricot computer to the U.S. The $3100 computer includes 256K bytes of RAM, two 3½-inch disk drives, a two-line LCD on the keyboard, and a 9-inch monitor. . . . **CompuSource Inc.** introduced the Abacus, a $2045 portable computer that it says can run most IBM, Apple, and CP/M software. . . . **Morrow** announced a portable version of its Micro Decision computer. The Portable MD3 includes 64K, two 5¼-inch floppy-disk drives, and a built-in monitor for $1899. Morrow also introduced an 8088 coprocessor board for the Z80-based Micro Decision computers. . . . **Televideo Systems** introduced three new computers that it says are compatible with the IBM PC. The TPC II, a portable, and the Tele-PC 1605, a desktop computer, include 128K bytes of RAM, two 5¼-inch floppy-disk drives, and a monitor for $2995. The Tele-XT 1605H replaces one floppy-disk drive with a 10-megabyte hard disk and comes with 256K for $4995.

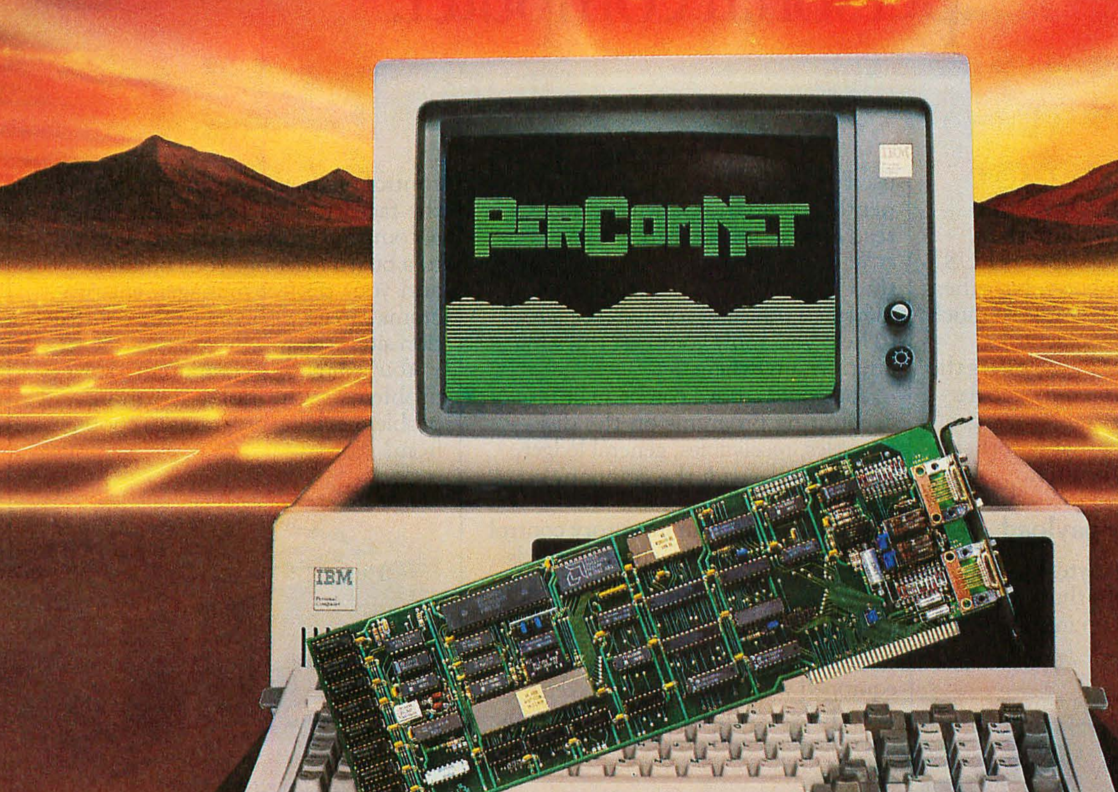
. . . AND WITH NEW DESKTOP MACHINES

Televideo Systems also unveiled a Z80-based four-user system that costs $6600. With a 10-megabyte hard disk and one terminal, the basic TS-804 sells for $4495. . . . **Handwell Corp.** introduced a computer that it says is operationally compatible with the IBM PC. With a color display, two serial ports, one parallel port, and one floppy-disk drive, the Handwell PC will sell for $1995. . . . **Logical Business Machines** introduced the L-XT, a $5985 computer that includes a 10-megabyte hard disk, 192K bytes of RAM, and Logical's Natural Language environment. . . . **Computer Designed Systems Inc.** unveiled the Adviser Micro Plus, which includes a built-in dot-matrix printer, one 5¼-inch floppy-disk drive, and a Z80 processor for $1995. The computer is also available with 68000 and 8086 processors for $4995. . . . **Kaypro** brought out the Robie, a desktop version of its Kaypro 4 portable computer that uses two Drivetec high-density 5¼-inch disk drives. With 5.2 megabytes of floppy-disk storage, the Robie will sell for $2295.

NANOBYTES

Apple Computer Inc. lost a copyright suit against an Australian computer dealer that sold the Taiwan-made Wombat computer, an Apple-compatible machine reportedly selling for about one-third of the Apple's price. Apple was told by an Australian federal court that computer ROM programs are not literary works and couldn't be protected by Australia's copyright laws. . . . **Digital Equipment Corp.** has unveiled its DECtalk voice synthesis module, a $4000 system that reads standard ASCII text. DECtalk attaches to an RS-232C port, generates high-quality speech, and includes heuristics that enable it to guess, for example, whether "St." stands for "Street" or "Saint". . . . **Canon U.S.A.** has announced an eight-page-per-minute laser-beam printer. The printer, which will be sold only to other manufacturers, is expected to retail for about $3000. . . . **Bank of America** has announced HomeBanking, a service available to northern California customers using a terminal or home computer, for $8 per month. . . . **American Micro Products** has introduced a $99.95 MVP FORTH compiler for the TRS-80 Model 100 portable computer. . . . **Gold Hill Computers Inc.** introduced GCLISP, a $375 LISP interpreter for the IBM Personal Computer. . . . **Micro Software International's** PractiCalc II, a $69 spreadsheet program with some database-management features, is available for the Apple II. . . . **National Microware** has introduced the Personal Planner, a home software package allowing users to write letters and keep track of appointments, names and addresses, and expense records. For MS-DOS or CP/M, the Personal Planner will sell for $149. . . . **Atari** and **Activision** announced a joint venture to distribute software electronically to home video-game and computer systems. Following a market test, the service is scheduled to begin later this year. . . . **Nelma Data Corp.** introduced Black Magic, a wireless local-area network that uses UHF FM "radio modems." Up to 256 computers with RS-232C ports can use the network for about $250 per node. . . . **Structured Systems Group Inc.** is selling WindowMaster, a $295 multitasking windowing environment that enables CP/M-86 and MS-DOS applications to run concurrently. WindowPack, which bundles WindowMaster along with SSG's word processor, spreadsheet, and database manager, sells for $495. . . . **Computer Associates International** has introduced integrated windowing software linking IBM Personal Computers to mainframes. CA-Executive includes database-management, word-processing, spreadsheet, graphics, and other software packages, some of which correspond to CAI mainframe packages. CA-Executive will sell for $1295.

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Introducing COMPAQ PLUS, the first high-performance portable personal computer.

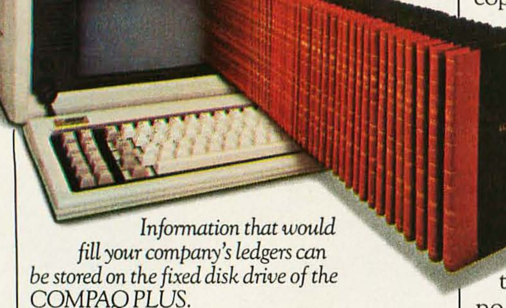
The makers of the COMPAQ™ Portable Computer, the industry standard, announce another breakthrough—the COMPAQ PLUS™ Portable Personal Computer. No other personal computer can handle so much information in so many places.

The new COMPAQ PLUS offers the power of an integrated ten-megabyte fixed disk drive in a portable. You get problem-solving power that no other personal computer can match.

Plus a bigger payload

How much is ten megabytes?

Enough to tackle jobs that can't be conveniently handled on most personal computers.



Information that would fill your company's ledgers can be stored on the fixed disk drive of the COMPAQ PLUS.

A mailing list of 100,000 names, addresses, cities, states, and Zip codes.

A full year of daily prices for every stock on the New York exchange.

Inventory records on a quarter million items.

The entire San Francisco phone book. And room left over for Peoria.

The fixed disk drive keeps all the information seconds away, ready to be searched, sorted, retrieved, analyzed or updated.

Plus better use of your time

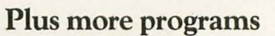
The integrated fixed disk drive will store programs. That means your most used programs and data can be permanently kept in the COMPAQ PLUS, ready to call up and run.

With programs permanently stored, the COMPAQ PLUS becomes a well-informed traveling companion, a tool to help you apply your best thinking anytime, anywhere.

You could store a complete library of accounting programs on the disk—payables, receivables, general ledger, and payroll—*with* the company's books.

You could store an inventory control program with your inventory records and a list management program with your mailing list and a filing program with your personnel files.

The COMPAQ PLUS is also equipped with a 360K byte diskette drive for entering new programs, copying data files, and making backup copies.



Plus more programs

More programs means more versatility. And the COMPAQ PLUS is impressively versatile because it runs all the popular programs written for the IBM® Personal Computer XT, available in computer stores all over the country. And they run as is, with no modification whatsoever.

And the high-capacity portable multiplies the productivity of every program it runs. Your inventory and its control programs can go with you to the factory. Your books and your accounting programs can go with you to a board meeting. Your building specs and your project management programs can go with you to the construction site.



The COMPAQ PLUS runs all the popular programs written for the IBM Personal Computer XT.

You're buying a computer to solve problems. Why not have more problem-solving programs to choose from?



Specially designed shock isolation system protects the fixed disk from jolts.

Plus a traveler's toughness

Life can be tough on the road. A true portable has got to be tougher. The COMPAQ PLUS is.

Its integrated fixed disk drive is unique, designed specifically to travel. Rough roads and hard landings don't bother it because of a specially designed shock isolation system that protects the disk from jolts and vibration.

All the working components are surrounded by a uniquely cross-membered aluminum frame. This structure, common in race car design technology, strengthens it side-to-side, front-to-back, and top-to-bottom.

The outer case is made of LEXAN®, the same high-impact polycarbonate plastic used to make bulletproof windows and faceplates for space suit helmets.

Does a portable personal computer really have to be this tough? Take a good look at your briefcase and then decide.

Plus ease of use

The COMPAQ PLUS is big where it counts.

The display screen is big. Nine inches diagonally. Big enough to show a full 25-line-by-80-character page that's easy to read even if you're leaning back in your chair.

The keyboard is full-sized and typewriter-style for easy control.

With its built-in display, the COMPAQ PLUS makes a smooth, low profile on your desk, not an obstacle that you have to talk around.

Plus an easy way to get started

If you're buying your first personal computer and you're not sure how much capacity you need, your choice is easier now.

Start with the COMPAQ Portable with single or double 320K byte diskette drives. If you need more capacity later, upgrade to the COMPAQ PLUS. A conversion kit is available that turns the COMPAQ Portable into a COMPAQ PLUS, complete in every detail and capability.

Plus a lot more

The COMPAQ PLUS also works with optional printers, plotters, and communications devices designed for IBM's personal computer family.

It has two IBM-compatible slots for adding optional expansion boards. With companion programs, they'll let you share information with a network of personal computers in your office, communicate with your headquarters computer files while you're away, or add memory capacity if your needs grow.

The problem-solving power of a high-performance desktop personal computer can now go where you need it.



It's got high-resolution graphics and text on the same screen. A detached keyboard. Programmable function keys. Expandable memory. Dozens of other features that simply make it do a better job of personal computing.

And when you see all that the COMPAQ PLUS has to offer, you'll be pleasantly surprised by the price. The fact is, it costs hundreds less than comparably equipped desktop personal computers.

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- ☐ One integrated 10-megabyte fixed disk drive
- ☐ One 360K byte diskette drive.

Software
- ☐ Runs all the popular programs written for the IBM XT.

Memory
- ☐ 128K bytes RAM, expandable to 640K bytes

Display
- ☐ 9-inch diagonal monochrome screen
- ☐ 25 lines by 80 characters
- ☐ Upper- and lowercase high-resolution text characters
- ☐ High-resolution graphics

Interfaces
- ☐ Parallel printer interface
- ☐ RGB color monitor interface
- ☐ Composite video monitor interface
- ☐ RF modulator interface

Expansion board slots
- ☐ Two IBM-compatible slots

Physical specifications
- ☐ Totally self-contained and portable
- ☐ 20"W × 8½"H × 16"D

For the name of the Authorized Dealer nearest you, call 1-800-231-0900.

The COMPAQ Portable, the industry standard in portable personal computers. ▼



The new COMPAQ PLUS, the first high-performance portable personal computer. ▼





More on the Morrow

After reading Tom Wadlow's review of the Morrow Micro Decision (October, page 306), I feel that a few points need additional comment. I own an early single-drive version MMD that I am not entirely satisfied with.

Mr. Wadlow states that all versions use Tandon drives. This is not true. Although double-sided drives may be supplied by Tandon, the single-sided ⅔-height drives are Shugart SA 200s.

Mr. Wadlow stated that the system uses a single-density format. This is also incorrect. The format uses 20 sectors with 256 bytes per sector, giving the disk a total of 204.8K bytes. The usable space per disk is 186K bytes or 390K bytes for double-sided drives.

The author also mentions the virtual drive and menu-driven CP/M features. These are nice additions to the system; however, they do not function properly. The virtual drive will respond with a prompt to exchange disks, but this prompt will remain on the screen after the exchange is complete. This is annoying, especially when multiple disk exchanges are required. With programs such as Logicalc and Pearl, it makes it hard to analyze the data that is on the screen.

The menu-driven front end for CP/M is equally disappointing. Many of the optional file-manipulation commands such as PIP and ERA are supported by this driver. However, these selections will not work. This doesn't present a problem for knowledgeable users of CP/M, but for beginners it can present a problem. This obviously makes the entire program useless. The program could easily be fixed. However, Morrow neglected to provide any documentation on its Pilot language.

Mr. Wadlow also mentions that the system can be used with almost any popular terminal. Although I have tried only two terminals, I have found that the Logicalc program will not adapt to an ADM-3A. The terminal setup program provided with the system is also disappointing. To achieve all the features of my Televideo required setting up Wordstar and Logicalc with their individual setup routines. I think Morrow has realized this problem because it no longer advertises the system without a terminal.

As for hardware design, the lack of schematics or cooperation from Morrow prompted me to analyze the circuits and draw my own set (a tedious process). After analyzing the drawings I am totally amazed that the system even works. This isn't the worst design I have seen, but it is close.

In conclusion, I can only say that I wouldn't recommend this machine to anybody. There are too many bugs in the system that should have been fixed long before the machine was marketed. The problems are obvious and I can't understand how Mr. Wadlow or Morrow could have missed them. I must also conclude that the author did a very poor job on this review.

Don Hair
6208 Adel Cove
Austin, TX 78749

Tom Wadlow responds:

You are right about the Shugart drives. Indeed, all the Micro Decision drives are manufactured by Shugart and not by Tandon, as I mistakenly claimed in the review. The drives used in the Morrow Decision 1 are manufactured by Tandon. As for the rest of your comments:

I believe that if you read the second page of my review, under the paragraph titled "Disk Storage," you will see that I did not *say that all Micro Decisions use single-density drives.*

The virtual drive feature of the Micro Decision is implemented in the operating system and cannot know very much about individual applications. It would be nice to have the pop-up display you describe, but let's look at what would be involved in doing so on the Micro Decision. To be able to restore the screen to its previous condition when the message goes away, you would have to save any text that might be overwritten. Perhaps your terminal might have a way to do this, probably not. So you would probably have to cause the terminal to send back the contents of the affected area over its serial line. This means that the Micro Decision disk driver would require an intimate knowledge of the terminal (since the text must be both saved and restored in the right place), which implies either yet another configuration program or a hard-wired dependence on only one specific terminal. Both of these alternatives are poor choices if you want to make the system reasonably flexible. I see virtual drives as an operating-system feature intended to make a bad situation (not enough disk drives) more tolerable. Most systems don't even go this far in trying to help.

Your complaints about the menu system and lack of documentation in both hardware and software echo what I said in the review. Morrow's major failing, with the Micro Decision as well as its more powerful Decision line, is its lack of adequate documentation. Unfortunately for us, Morrow is far from alone in this. And as I said in the review, you really need to be somewhat familiar with CP/M to use the Micro Decision. As for Pilot documentation, a call to Morrow Customer Service yields the news that a Pilot manual is now available. Write or call Morrow for information on how to get it.

As for the problem of incompatible terminals, I said that the Micro Decision can be used with most popular terminals, and I suspect that statement still holds true. But if you intend to replace the terminal that Morrow has designed the system around, you should not be surprised at installation difficulties. Morrow does claim to have successfully configured a Micro Decision to run with an ADM-3A. Incidentally, Morrow is now offering the Micro Decision with a Liberty terminal, which has a much nicer keyboard and display than the ADM-20 shown in the review.

I have absolutely no complaints about the hardware of the Micro Decision, other than the design omissions (such as separate printer and modem ports). The disks were fast and quiet, the system unit was rugged and never seemed to have power-up problems. Regardless of what the schematics (or at least your version of them) say, a system that performs as this one does is adequately designed. Morrow designed this system for users who are unlikely to be concerned over the elegance of a particular part of the disk controller or the chip count of the RS-232C circuitry. I agree, however, that such things should be obtainable from the manufacturer, and, indeed, they are. The Morrow Micro Decision Service Manual *($225) provides complete schematics, test information, and diagnostic software. Once again, write or call Morrow at 600 McCormick St., San Leandro, CA 94577, or (800) 521-3493 for more information.*

I still stand by my recommendation. The Micro Decision is not a good system for the computer hobbyist/experimenter. Nor is it a good system for the novice user. But it is serviceable for the minimally experienced computer user who wants a small, quiet, fairly fast desktop system to run a few applications.

As for your final comments: I guess you just can't please everybody. If my mail on this review is any guide, however, you are in the minority.

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**MS DOS is a registered trademark of Microsoft.

Circle 187 on inquiry card.

Ansi, uh, ANSI Standards

I have just spent a frustrating afternoon trying to install a piece of software into my computer system. As usual, the problem is that my terminal is not one of the ones on the list of choices. What makes it particularly frustrating is that my terminal conforms to the ANSI "mode" for terminal.

I would like to plead with software companies to please include the "standard" as one of the options. I would also like to plead with terminal companies to include the ANSI standard as at least one of the possible emulations that your new terminals can produce.

I realize that it is an imperfect world, but surely one might expect the ANSI specification to have some merit!

J. A. Koehler
2 Sullivan St.
Saskatoon, Saskatchewan
Canada S7H 3G8

Software Swap

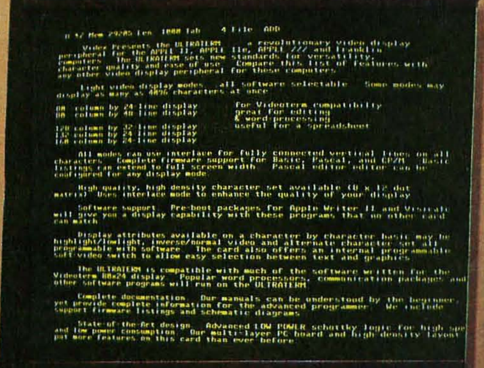
I read with great interest the letter "In Praise of Public-Domain Software" in the November BYTE (page 14). We have a large program-exchange system for Timex/Sinclair computers that is similar to public-domain software. The requirements are simple: choose the program you want from the list of available software, then make a copy of a program that you or friends have written or supervised and send it in. Your program will be added to the list of available software. We will send you the programs you have requested. Everyone wins! For more information on this service please contact me.

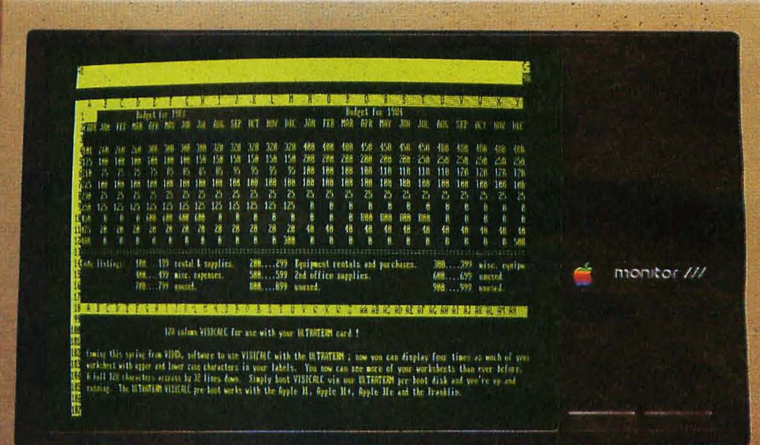
Billy Casebeer
President, Timex/Sinclair Users Group
POB 372
Oologah, OK 74053

An OS for the M68000 ECB

I enjoyed reading "The M68000 Educational Computer Board" by Robert Floyd (October, page 324). While I was a graduate student in computer science at the University of South Carolina, I was involved with a project that developed software for the Educational Computer Board (ECB). The professor of the operating systems course assigned several groups to develop operating systems for

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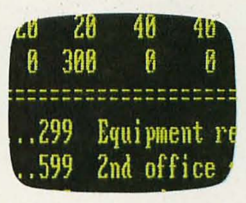


Photo of actual-size characters on Apple Monitor III.

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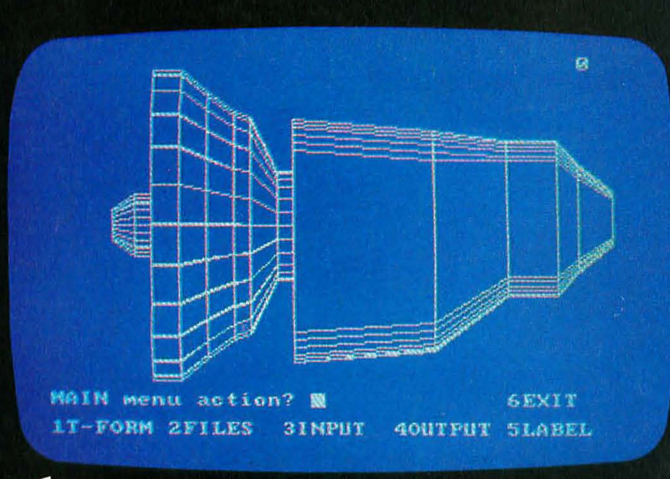
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UltraTerm features a built-in soft video switch and has complete firmware support for BASIC, Pascal and CP/M®. Use it with the Apple® II, Apple IIe, Apple III and Franklin.

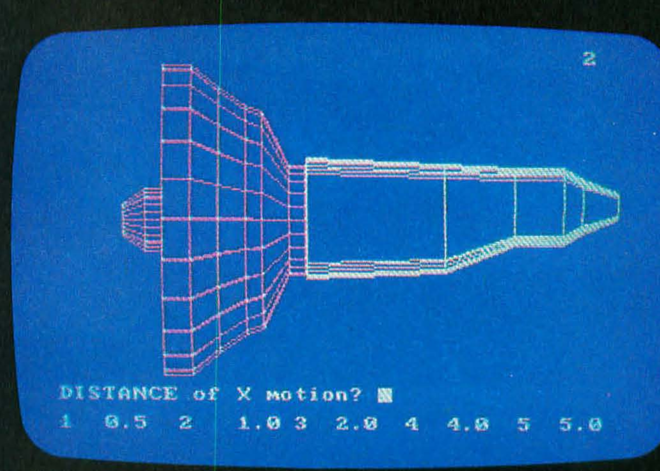
Apple and the Apple logo are registered trademarks of Apple Computer, Inc.

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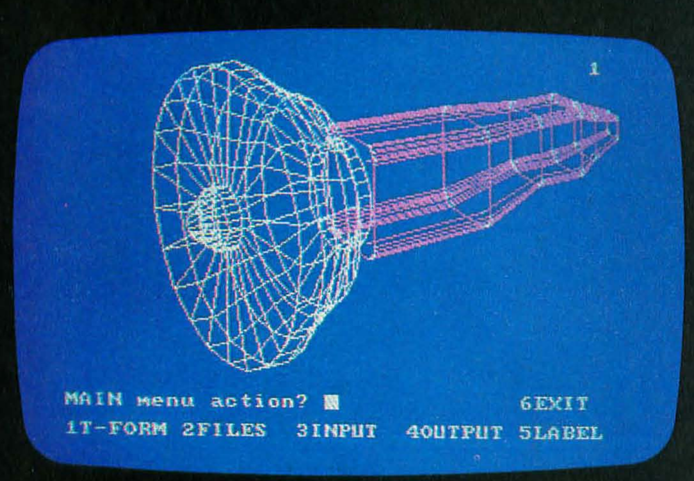
Circle 374 on inquiry card.



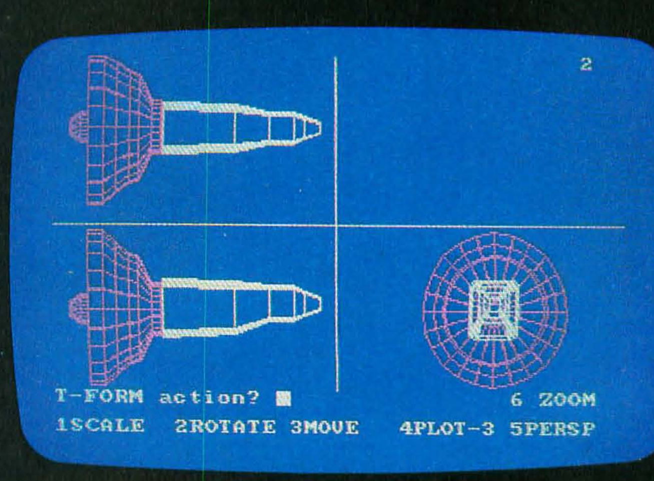
1 Create a 3-D object.



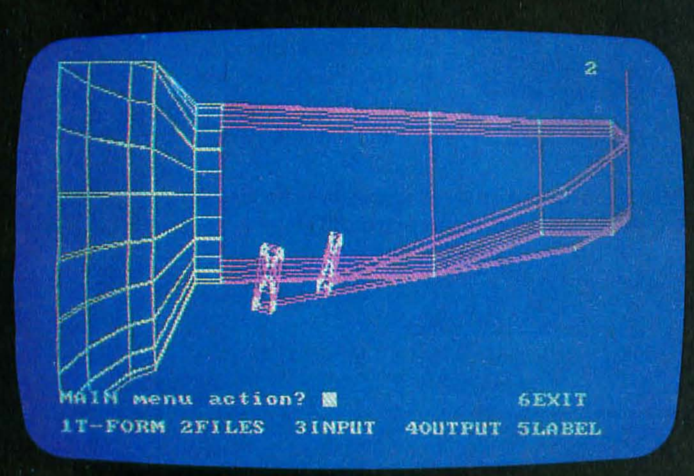
2 Modify it to get the best design.



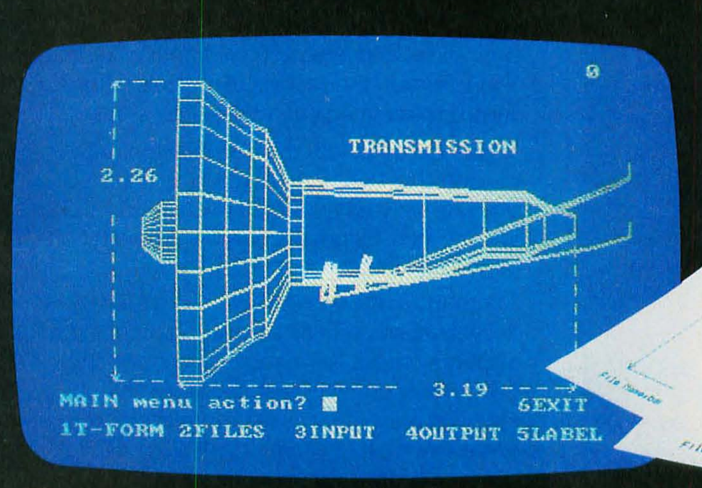
3 Rotate it to examine it from any angle.



4 Study it in 3 simultaneous orthogonal views.



5 Zoom in on part of it and add details.



6 Add dimensions and design notes before plotter output.

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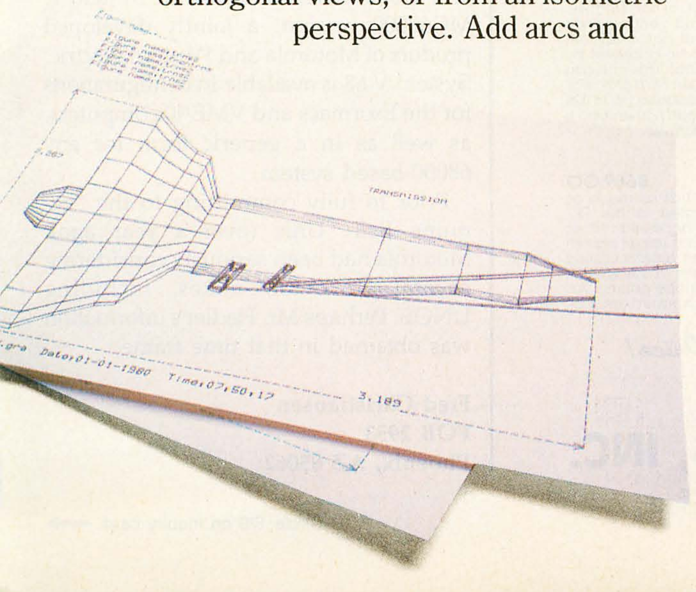
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the ECB. The major goal of each operating system was to implement concurrency.

The group I was involved with undertook a major task: to create an operating system in a short six-week summer school course. We were successful and implemented an operating system that we named OX (for Overnite Executive). OX is approximately 8K bytes long. The operating system consisted of a kernel, task manager, resource manager, and a memory manager. A spooler and several applications programs to prove concurrency were also developed. The code was developed in 68000 assembly language, Concurrent Euclid, and C, which was cross-compiled on a Unix system. The kernel, task manager, and various initialization was written in assembly language and C, while the larger managers were developed in Concurrent Euclid. The object code was then downloaded to the ECB in Motorola "S" record through the ECB serial I/O port.

As I have stated, the operating system was successful in demonstrating concurrency. This was done by allowing resident tasks to be dispatched in round-robin fashion at specific timer interrupts. A particularly neat feature of the operating system was the memory manager in which the respective managers and application programs allocated memory. Many hooks exist in the implementation to provide for additional resident tasks such as terminal-message tasks, and perhaps a memory-resident disk.

The project provided a hands-on insight into operating systems, and I must admit I had a great time hacking away. I have a complete set of documentation (57 pages) and the entire source-code listing. I would be happy to pass along this information to any hobbyist or educational institution. Please mail a stamped, self-addressed envelope to me and I will mail the documentation and source code of OX to you.

Mark Cates
8625 Windjammer Dr.
Raleigh, NC 27609

V/68 OS for All

I greatly enjoyed the October BYTE with its Unix theme. Although I am involved with the Unix operating system (porting Unix System V to the Motorola MC68000, under contract to Western Electric), I had not heard of Usenet before.

I submit the following comment as a reader, and not as a representative of Motorola Inc.

Contrary to the statement in David Fiedler's article ("The Unix Tutorial, Part 3: Unix in the Microcomputer Marketplace," page 132) that "[Charles River Data System's] own Universe 68 computer uses UNOS, as does Motorola on that firm's Versabus-based system," Motorola offers the System V/68 operating system. System V/68 is derived from Unix System V, MC68000 version, a jointly developed product of Motorola and Western Electric. System V/68 is available in configurations for the Exormacs and VME/10 computers, as well as in a generic form for any 68000-based system.

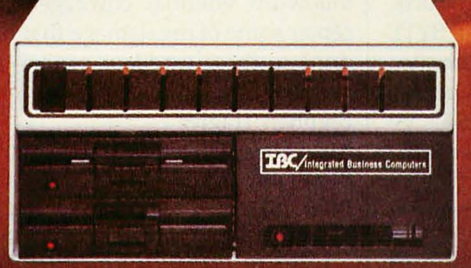
Prior to fully committing to the "genuine Bell" Unix (over a year ago), Motorola had been seriously considering several Unix look-alikes, including UNOS. Perhaps Mr. Fiedler's information was obtained in that time frame.

Fred Christiansen
POB 2953
Phoenix, AZ 85062

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Supersoft Speaks Up

I am compelled to respond to your reviews of the Supersoft C compilers for CP/M-86 and MS-DOS, which ran in the August BYTE ("Comparing C Compilers for CP/M-86" by Jerry Houston, Jim Brodrick, and Les Kent, and "Nine C Compilers for the IBM Personal Computer" by Ralph Phraner). Both reviews were outdated, misleading, and contained serious inaccuracies and omissions. They did a disservice to your goal of giving BYTE readers timely information about available C compilers.

In 1982, Supersoft released the first C compiler for CP/M-86 and MS-DOS. This release was preliminary and temporary; its purpose was to let customers of Supersoft's CP/M-80 C compiler be the first to transport their applications to CP/M-86 and MS-DOS. At that time, we were using the compilers in house to transport our own applications to 16-bit systems; we knew they would be useful to others for this purpose. We also knew they would undergo major enhancements, both in the documentation and the programs themselves, before being released as general development compilers under CP/M-86 and MS-DOS.

In March 1983, after the initial purpose had been served, our CP/M-86 and MS-DOS C compilers were withdrawn from the market for further development. In August 1983, just as we were about to release our new and substantially enhanced versions of these compilers, two reviews appeared in BYTE magazine on our preliminary releases. We were surprised to see these reviews in print because we had not been notified in advance by BYTE and the products being reviewed had not been available for five months.

Though the initial versions of our compilers did have some weaknesses that we acknowledge, at the time of their release they served a valuable purpose that easily outweighed their shortcomings: they sped C programmers into the rapidly emerging 16-bit world. This, our main consideration in releasing the products, was completely overlooked in the BYTE reviews. In addition, our new C compiler, greatly enhanced and uniformly available under CP/M-86, CP/M-80, and MS-DOS, has several strong points that make it the most attractive C available. We are providing this new version to all purchasers of the preliminary CP/M-86 and MS-DOS C compilers at no charge.

Through our internal experience with Supersoft C, we consider it to have many advantages over other C compilers: these advantages include the widest array of library functions (all delivered in source form as well as library form), high reliability due to extensive testing, uniform availability under several operating systems, and close adherence to the Unix standard syntax. These advantages and others were largely overlooked by the BYTE reviewers. In addition, technical inaccuracies and omissions that appeared in the reviews actually gave our initial releases less credit than they were due.

We were disappointed that these untimely and misleading reviews should appear in a typically fine publication like BYTE. We hope that this letter and other follow-up editorial coverage can help repair some of the damage that has been done to these excellent products.

Stephen Hagler
Marketing Director
Supersoft Inc.
POB 1628
Champaign, IL 61820

Jerry Houston replies:

I am sorry that Supersoft considers my review of the CP/M-86 C compiler a disservice to BYTE readers, because considerable time and effort went into trying to produce the opposite result. If I failed to supply something useful, I apologize to BYTE's readers and to Supersoft.

A few words in defense of my review. Supersoft says that the version of the compiler I reviewed was "preliminary and temporary" and that a greatly improved version was released in August 1983.

The lead time for submitting articles to BYTE magazine is months, not weeks, in advance, and the review in question was submitted several months before August 1983. Lack of timeliness is the penalty for long lead times. The benefit is generally excellent editorial content.

We purchased our copy of the Supersoft C compiler COD in 1982 in response to an ad in BYTE. Nowhere did the ad or the documentation indicate that the product was in any way temporary or preliminary. In fact, the ad said of the $500 C compiler: "The optimizer typically results in 40% code reduction. This means that compiled object code will run nearly as fast as that which was written in

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assembler." The documentation listed the version we received as "Version 1.1."

None of this suggested to us that the compiler was preliminary. In January 1983 we asked a representative of Supersoft whether a newer, more functional version of its compiler was coming out, and we were told that nothing was planned for about six months. Since our review was due in one month, we reviewed what existed, not what was planned.

Supersoft also states that, "We are providing this new version to all purchasers of the preliminary CP/M-86 and MS-DOS C compilers at no charge." On September 7, 1983, we phoned Supersoft, gave them our serial number, and asked what was involved in upgrading to the latest version of the compiler. We were informed that we should send our original disk plus $50. This is a more than reasonable charge, but $50 is not free.

Supersoft's claim to offer "close adherence to the Unix standard syntax" is not justified in the version reviewed. It fails to support longs, statics, or initializers. This is comparable to a version of BASIC that has no FOR statement.

Supersoft has some excellent products. The product I reviewed is not one of them. If my review conveyed that idea, then it was not "misleading." If my article tended to lead potential unhappy customers away from the product under review, then I believe it was a service both to Supersoft and to BYTE's readership.

Watch the Fine Print

Recently I decided to abandon my Apple-based system and buy an IBM PC XT. It's not that I'm unhappy with my Apple. On the contrary, it has been a reliable tool that has paid for itself many times over during the last four years. However, the mining industry (for which I write software) has developed a case of IBM myopia that requires that I develop programs for the PC.

My first step in making the IBM transition involved obtaining information concerning the UCSD p-System (for which I have developed a large library of software). Although the sales representative was unfamiliar with the concept of an operating system, he was kind enough to send me IBM's "Software Fact Sheet" and a price list. This fact sheet contains some fine print concerning the p-System that I would like to bring to the attention of your readers: "Neither the program nor its data files can be stored on a fixed disk." Incredible! Here's a big and powerful corporation with a sense of humor. Imagine if GM had the guts to include some jokes of this caliber in its sales literature like "The optional MZD Turbo engine only works in the neutral gear." Three cheers for IBM! Now, I've got to remember where I stored that literature on the Sage IV.

James P. Reed
Rockware Inc.
7195 West 30th Ave.
Denver, CO 80215

In Defense of the Model 16

Regarding the letter from Marvin Stone and Sam Harp (October, page 20) concerning the relative speeds of the MC68000 and Z80 in the Radio Shack Model 16 computer: Mr. Hurrell's response is quite correct about the particular benchmarks used. The Xenix MBASIC is very slow for floating-point

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computation. The increased accuracy is a blessing or a curse, depending on your needs.

The screen-updating benchmark timing cited is an unfortunate side effect of the hardware. The only way in which the 68000 can get to the screen RAM is via the Z80, and this added overhead can only slow down accesses, no matter how fast the 68000 may be.

As far as the SIN benchmark, perhaps Mr. Harp or Mr. Stone may want to consider switching to FORTRAN. I ran the published SIN benchmark (TRSDOS: 43 seconds; Xenix: 132 seconds) on a Model 16 under Trisoft CP/M-68K and ANSI FORTRAN-77. The time was 5.2 seconds!

James M. Knox
Trisoft
4102 Avenue G
Austin, TX 78751

The interesting thing to me about the Harp & Stone Benchmark study of the TRS-Xenix MBASIC was how slow *all* the listed processors were. I ran Benchmark I on the Z8000-based Olivetti M20, using Microsoft BASIC, in 8.9 seconds. Going to double precision by inserting "defdbl A-B, Z" at the beginning lengthened the time to 9.5 seconds. I believe the running time is this low because Olivetti MBASIC performs only trigonometry and exponential functions in single precision.

Examining Z after running the program shows a value of 0.998048.

S. Richard Mateosian
Consultant, Computer Systems
2919 Forest Ave.
Berkeley, CA 94705

After reading "TRS-80 Model 16 Problems" (Letters, October, page 20) and the response from Radio Shack, it is evident that a simple fact needs to be straightened out.

Suppose one used a Z80 to handle the I/O for a CRAY. Would it output characters any faster than a 68000 making similar requests?

This elementary consideration shows the absurdity of the Harp/Stone "benchmark." Their negative remarks about the capabilities of the Model 16 and Xenix are therefore worthless and should be retracted.

Joel Rice
486 Route 9W
Nyack, NY 10960 ■

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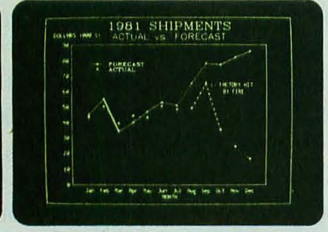


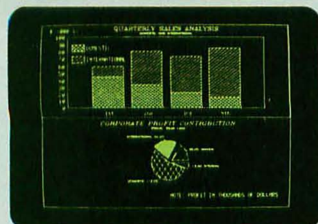
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Call toll free: 1-800-421-2207. In California only call: 1-800-262-1221
Source Number: TCT-654

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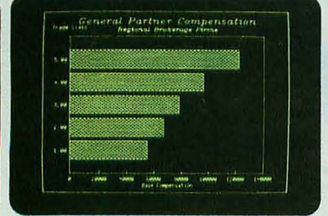
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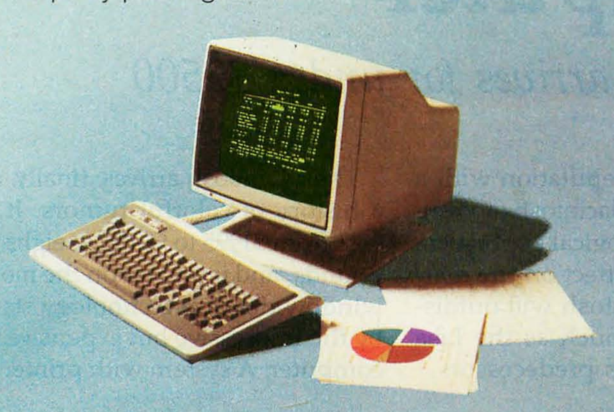
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Base System Price[1]	$2,695	$2,750	$2,390	$3,999	$3,495
Serial Port (RS232)	STANDARD	$119	$195	2 STANDARD	2 STANDARD
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COMPLETE SOLUTION PRICE	$2,695	$3,928-$4,628	$3,465-$4,165	$5,496	$4,940-$5,540
Dual Drive Capacity	800 KB	640 KB	280 KB	2.5 MB	800 KB
Graphics Resolution	640 x 300	640 x 200	280 x 192	640 x 240	800 x 240
Keys on Keyboard	93	83	63	82	105
Expandable Memory	YES	YES	YES	YES	YES
Optional Winchester	YES	YES	YES	YES	YES
Tilt and Swivel Display	YES	NO	NO	NO	NO

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The Apple Macintosh Computer

Mouse-window-desktop technology arrives for under $2500

by Gregg Williams

Apple established itself as one of the leading innovators in personal computing technology a year ago by introducing the Lisa, a synthesis and extension of human-interface technology that has since been widely imitated. Now the company has strengthened that reputation with a new machine, the Macintosh (above). In terms of technological sophistication and probable effect on the marketplace, the Macintosh will outdistance the Lisa as much as the Lisa has outdistanced its predecessors.

The Macintosh arrives, finally, after a history of colorful rumors. It will cost from $1995 to $2495, weighs 22.7 pounds, and improves on the mouse-window-desktop technology started by the impressive but expensive Lisa computer. A system with printer and

second disk drive costs about $900 more, but even at that price, the Macintosh is worth waiting for.

The Macintosh at Work

Before we look at the Macintosh (or Mac) in more detail, let's look at how it works. When you turn the Mac on, its screen tells you to insert a 3½-inch Sony floppy disk. When you do that, the Macintosh puts a disk icon on the screen along with the disk's name. As with the Lisa computer, you first select an object, then choose a menu item that works on the object. Say, for example, we choose the disk by moving the cursor to the disk icon and clicking the mouse button once (figure 1a). The disk "opens up," showing a window containing icons, each one of which corresponds to an item on the disk. To start using the Mac Paint program, we select the Mac Paint icon and choose the menu item "open," as shown in figure 1b. (We also could have opened Mac Paint by double-clicking on the icon.)

What follows is a brief example of how the Mac Paint program works. When we open the program, we get the screen of figure 1c. The large blank area is a window onto the drawing area, the boxes on the left are tools, the boxes on the bottom row are patterns, and the lines in the corner are selections for the current line width. By selecting the "open oval" tool and the thickest line width, we can draw empty ovals with thick borders (figure 1d). By selecting the "paint bucket" tool and the "diagonal bricks" pattern, we can fill the oval with that texture (figure 1e). The "eraser" tool lets us erase part of the image (figure 1f); for finer control, we can give the FAT BITS command (figure 1g), which allows us to erase or paint on a pixel-by-pixel basis. When we are finished with our image and select the QUIT command, the program displays an alert box that asks if we want to save our changes (figure 1h).

Foundations of Macintosh Design

The Macintosh computer is built on three cornerstone ideas: second-generation Lisa technology, reliability and low cost through simplicity, and maximum synergy between hardware and software. Each of these ideas contributes significantly to the uniqueness of the Mac's design.

Second-Generation Lisa Technology

Without question, the strongest influence on the Mac is that of the Apple Lisa computer, which proved the viability of certain concepts in a commercial product: the *graphics/*mouse orientation, the desktop metaphor, the data-as-concrete-object metaphor, and the shared user interface between programs. The Mac has inherited these concepts; for further details on them, see my article, "The Lisa Computer System" (February 1983 BYTE, page 33).

Four differences between the Lisa and the Mac make the latter a second-generation computer. First, the Mac runs at a higher clock speed, 7.83 MHz (compared to the Lisa's 5 MHz). Second, the Mac, which has a smaller amount of memory to work with than the Lisa, uses its memory more efficiently because its programs and subroutines are coded in *68000* assembly language (as opposed to the Lisa, which uses less efficient 68000 machine-language programs that are compiled from high-level Pascal source code). Third, the Macintosh eliminates add-on peripheral cards and uses instead a high-speed serial bus that implements what Apple calls "virtual slots." (I will talk about this in greater detail below.)

The final difference is actually an important limitation of the Macintosh: it allows only one major application program to be active at a time (the Mac BASIC and "desk ac-

At a Glance

Name
Macintosh

Manufacturer
Apple Computer
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010

Dimensions
9.75 by 9.75 by 13.5 inches

Weight
Main unit, keyboard and mouse—22.7 lbs.

Power Requirements
105–130 V AC, 60 Hz (U.S. model); 85–135 V AC, 50/60 Hz (international model)

Memory
128K bytes of RAM, 64K bytes of ROM

Standard Configuration
Main unit with 128K bytes of RAM, 64K bytes of ROM, integral Sony 3½-inch disk drive, 9-inch video monitor, two serial ports; external mechanical mouse; external keyboard

Mass Storage
One Sony 3½-inch disk drive; 3½-inch disk holds 400K bytes and is encased in a rigid plastic housing

Video Display
9-inch monitor, noninterlaced 60.15-Hz image, 512- by 342-pixel resolution

Pointing Device
Mechanical mouse

Keyboard
Detached keyboard; 58 keys (59 in international version); autorepeat; two-key rollover

Hardware Options
Second disk drive, keypad, Imagewriter printer, security kit (for chaining computer to table)

Software Options
Mac Paint (drawing program), Mac Write (a simple word processor), Mac BASIC, Mac Pascal, others (see text)

Prices
Standard system, $1995–$2495; Mac Paint and Mac Write (together), bundled at no charge for the first 100 days, $195 (for the two) thereafter; Macintosh Pascal, BASIC, Logo, Terminal, and Assembler/Debugger, $99 each; Mac Draw and Mac Project, $125 each; keypad, $99; second disk drive, $395; Imagewriter printer, $495

Macintosh System Architecture

by Burrell C. Smith

Inside the Macintosh, hardware and software work together to provide a system capable of supporting high-performance graphics, built-in peripherals, and communication channels to the outside world. From the beginning of the Macintosh project, the product-design goals of small size, light weight, and moderate end-user cost encouraged us to create a low-power, low component-count design. The large number of I/O devices that are built into each unit, combined with our desire for high performance, caused us to explore many alternatives for each aspect of the hardware implementation. A cooperative spirit among the people working on the industrial design, analog electronics, digital electronics, and low-level software resulted in the synthesis of detailed implementations that combined strengths from each group, providing an integrated design solution for all aspects of the product.

The heart of the Macintosh digital electronics is the MC68000 processor and its memory (both RAM and ROM). In the Macintosh, the data-output lines from the system RAM drive a data bus separate from that used by the rest of the machine (see figure 2). The RAM is triple-ported; this means that the 68000, screen-displaying hardware, and sound-output hardware have periodic access to the address and data buses, so that the video, the sound, and the current 68000 task appear to execute concurrently.

ROM memory connects directly to the system data bus and is used by only the 68000. Much of the system's time-critical code, such as the low-level graphics primitives, operating-system routines, and user-interface routines, reside in ROM. Macintosh software calls this code through 68000 "line 1010 unimplemented" instructions, which get one of approximately 480 addresses from an address table stored in low memory; this effectively allows the ROM subroutines to function as extensions of the 68000 instruction set. Since the ROM data and address buses are used exclusively by the 68000, ROM is always accessed at the full processor speed of 7.83 MHz; consequently, the ROM can perform as a read-only cache memory.

The 512- by 342-pixel video display appears in memory as a linear array of 10,944 16-bit words of data, with the most significant bit representing the pixel farthest left. Each 512-pixel horizontal line consists of 32 words of data, with bits shifted out at 15.67 MHz (322.68 µs per 512-pixel line) followed by 12 words of horizontal blanking (taking 12.25 µs). The last memory bus cycle of each horizontal line is reserved for sound DMA, where a byte of sound data is fetched from the sound buffer and sent to the sound PWM (pulse-width modulator) for conversion into an analog level. The update rate of the sound channel is then equal to the video horizontal rate, or 22,254.55 Hz. In the vertical direction, 342 active scan lines are followed by a vertical retrace and enough inactive horizontal lines to take up the same time as 28 horizontal lines, providing a vertical retrace time of 1.258 ms. Although screen-memory accesses may occur at any time, a vertical retrace interrupt is generated at the falling edge of the vertical sync pulse to allow screen animation to occur completely synchronous to the video beam movement.

The product-design goals of small size, light weight, and moderate end-user cost encouraged us to create a low-power, low component-count design.

Access to RAM is divided into synchronous time slots, with the 68000 and video circuits sharing alternate word accesses during the live portion of the horizontal video-display line and the sound circuits using the video time slot during the last memory bus cycle of the horizontal line. Although the access to RAM is divided three ways, the 68000's share is maximized by giving it access to unused cycles during horizontal and vertical blanking. This way, 68000 access to RAM averages to a speed of about 6 MHz.

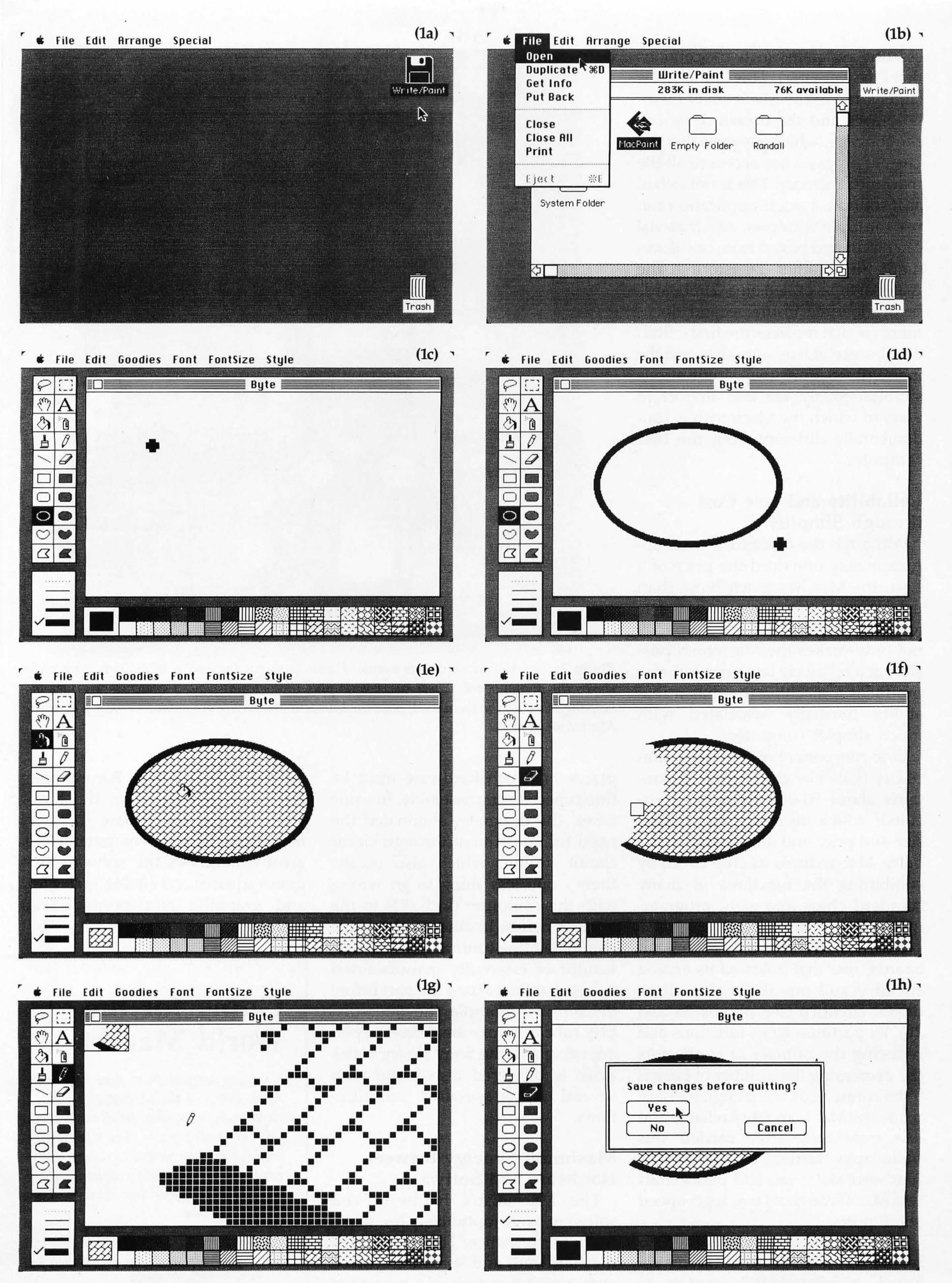
For high-performance sound generation, a tightly coded routine generates 370 samples of sound data and places them into the sound buffer just after a vertical retrace interrupt. The 68000's 32-bit registers are used to control pitch with 24 bits of precision, providing each of four possible voices with 16,777,216 possible frequencies. For simpler sounds, a timer in the system's VIA provides a square wave of programmable pitch. All sounds pass through a software-controlled volume adjustment that creates approximately 20 decibels of total amplitude variation in eight discrete steps.

The Macintosh disk controller is a single LSI (large-scale integration) component referred to as the IWM ("integrated Woz machine") chip. The device, a one-chip integration of the disk controller originally designed by Steve Wozniak for the Apple II, handles data at 500 kilobits per second. To control the disk drive's motor speed, a pulse-width modulator located on the digital board allows the disk to move at one of 400 possible disk motor speeds; the PWM is driven from a table in memory in a fashion similar to that of the sound system. By varying the motor speed, we created a more reliable disk drive that puts significantly more data on the same disk.

The Macintosh communications chip, the Zilog 8530 SCC (serial communications controller), provides synchronous and asynchronous data transmission at up to 230.4K bits per second using a self-clocking data format and up to 1 megabit per second using an external clock. The Macintosh's two serial ports are identical; each provides single-ended or differential signaling and multidrop (party-line) capability.

The 6522 VIA (versatile interface adapter) rounds out the I/O requirements of the machine by providing system timers, support for the mouse and keyboard, and general-purpose I/O lines for selecting various system functions such as alternate screen and sound buffers and for communicating with the system's real-time clock and parameter memory.

Burrell C. Smith is a member of the Apple Macintosh design team.



Figures 1a–1h: *Working with Mac Paint on the Macintosh computer. See text for details.*

cessory" programs are two exceptions that I'll cover later). This limitation is largely due to the Mac's small memory space and the overall design of the software, which assumes that the current program has access to all the machine's memory. This is not as bad as it sounds; a single application can use multiple windows, and material can be cut and pasted from one document to another by storing the material to be pasted on a "clipboard" before loading in the second document (which replaces the first). Still, the absence of hardware slots and the inability to run two applications simultaneously are two important ways in which the Macintosh is fundamentally different from the Lisa computer.

Reliability and Low Cost through Simplicity

Although the Macintosh costs approximately one-third the price of a Lisa, the Mac has much more than one-third of the Lisa's power. The idea of reliability through simplicity not only makes the Macintosh possible at a relatively low price but also produces a machine that has a reliability normally associated with much simpler computers.

One component of the Mac's simplicity is its low chip count—it contains about 50 ICs (integrated circuits), which decreases its physical size and price and increases its reliability. Mac reduces its chip count by combining the functions of many standard chips into eight programmable-logic arrays (PALs).

The Macintosh has only two circuit boards, one that holds all its analog circuitry and one that holds all its digital circuitry (see photos 2a and 2b). By partitioning its functions and reducing the number of connectors (by decreasing the number of boards to be connected), the designers have made the Mac both more reliable and less expensive. They carried this philosophy farther by eliminating hardware slots; you add peripherals to a Mac through its two high-speed serial ports.

The Macintosh was designed to reduce (or, in the case of the digital board, eliminate) the number of places in which hardware must be fine-tuned during assembly. In some cases, the designers eliminated the need for adjustment through clever circuit design, which also means there's one less thing to go wrong with the computer once it is in the owner's hands. In other cases, Apple eliminated fine-tuning by requiring a vendor of externally manufactured subassemblies to tune the part before delivery; for example, the video-display tube and yoke are delivered preadjusted, and the Sony 3½-inch disk drive is delivered tested and with several Apple-specified modifications.

(2a)

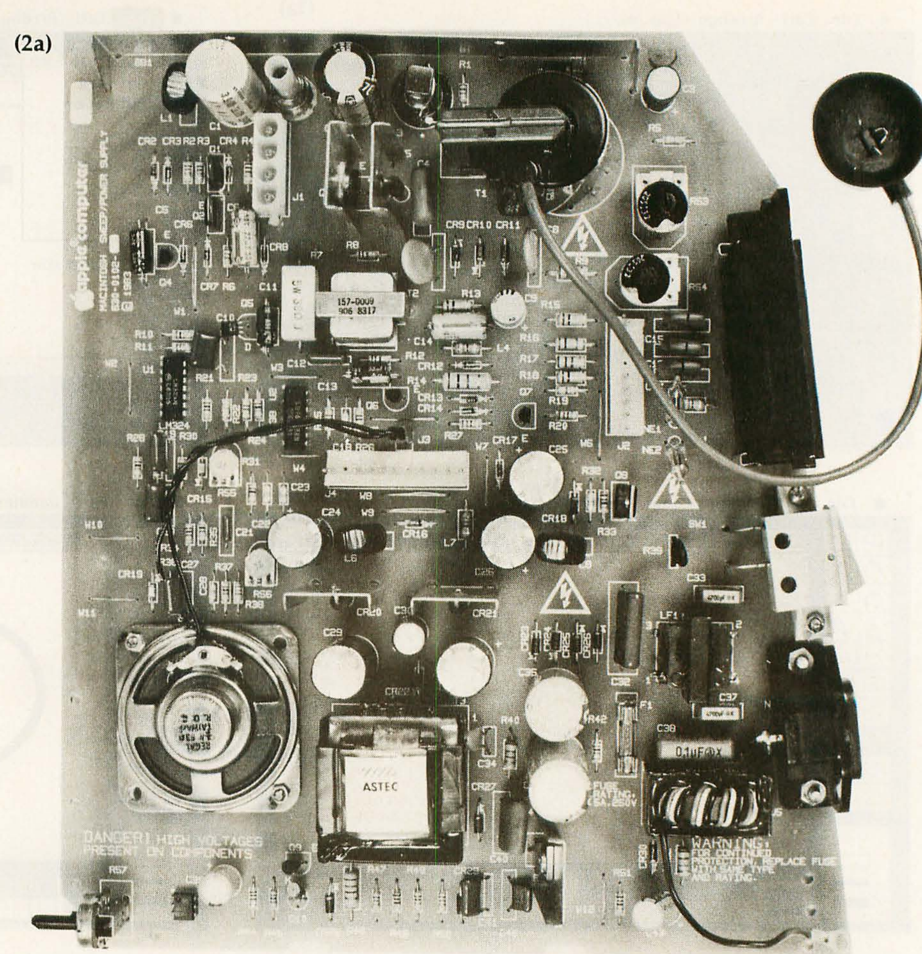


Photo 2: *The Macintosh circuit boards. Photo 2a shows the analog board, while photo 2b shows the digital board. These two boards plus the video display, 3½-inch disk drive, and housing make up the main unit; only the keyboard and mouse are needed to make a complete Macintosh system.*

Maximum Synergy between Hardware and Software

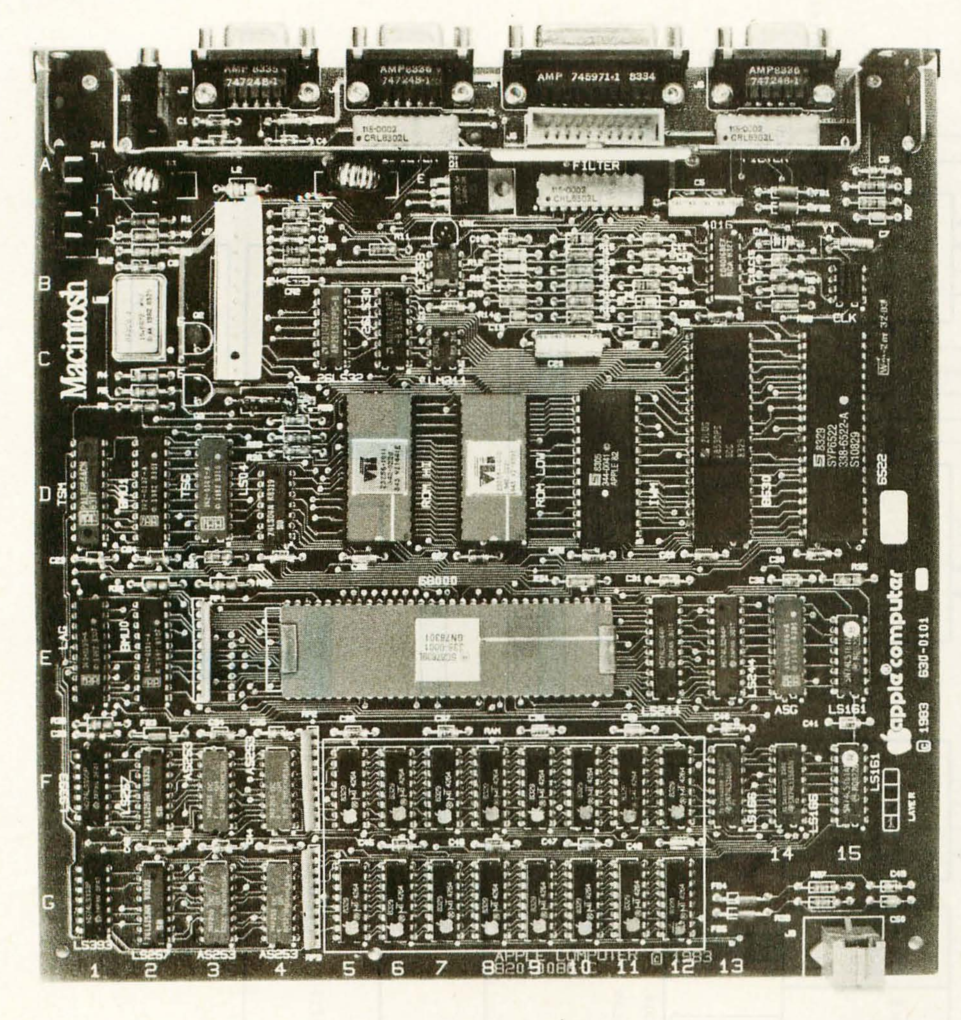
The Macintosh's hardware and software were optimized for maximum performance. This means that the hardware and software evolved over a period of time in a process of mutual give and take. For example, the pixels displayed on the Mac's video display are square (not rectangular, as in other computers); this greatly simplifies the software that draws squares and circles, scales text and graphics, and prints screen images.

Going for the World Market

Having learned from past experience, Apple designed the Macintosh so that it could easily be modified for all markets outside the United States. The following examples show how pervasive nation- or language-specific aspects of a computer design are and how Apple has minimized the changes needed.

- *Except for the word "Apple" on the rear panel, the Macintosh has no English text*

(2b)



Hardware

The main unit of the Macintosh consists of eight parts: two circuit boards, a cable to connect them, a metal chassis, a 3½-inch disk drive, a video-display tube with yoke, and a plastic front bezel and rear housing (see photos 3a and 3b). An external mouse and keyboard make for a total of 10 parts. The main unit takes up an amazingly small 10-inch by 10-inch area (it is 13½ inches high). True, the keyboard and mouse take up more area than that, but the footprint of the main unit is considerably smaller than that of comparable computers. The Mac is also pleasantly compact and light; an entire Mac system in an optional padded satchel weighs 25.6 pounds (less than many transportable computers) and can be carried onto an airplane.

Figure 2 shows a block diagram of the Macintosh hardware; for more details, see the "Macintosh System Architecture" text box. For now, let's look at the machine's major subassemblies:

Processor: The Macintosh uses a Motorola 68000 processor running at 7.83 MHz.

Video display: The Mac has a 9-inch monitor that displays a noninterlaced image at 60.15 Hz. The resolution of the video image is 80 pixels per inch, so the overall screen is 512 by 342 pixels.

ROM: The Mac uses two 256K-bit ROMs configured as 64K bytes of memory. The ROM (read-only memory) contains most of the Mac's operating system and a "toolbox" of optimized 68000 user interface related routines (see the text box "The User Interface Toolbox" for more detail). The ROM is always accessed at full speed, 7.83 MHz.

RAM: The Mac has 128K bytes of memory; at some point (Apple says by the end of 1984), this will be expandable to 512K bytes (by substituting 256K-bit dynamic RAM (random-access read/write memory) chips for the 64K-bit chips currently being used). The screen display uses 21,888 bytes and is drawn using this memory and DMA (direct memory access) circuitry. Apple has an un-

Text continued on page 39

anywhere on the product or in the ROM. Each plug is labeled with a picture that identifies its function.

•The video-display rate of 60.15 Hz is generated internally instead of being derived from the line current. This allows the Mac to be used without modification in countries that have 50-Hz line current.

•Macintosh software has been designed so that all text messages, message layouts, and icons can be stored in a resource file, separate from the program itself. A designer can use a resource-editor program to change text (for example, to another language), icons, message layout, and the formats of time, dates, numbers, and currency. With this method, the program itself does not have to be changed and recompiled to make these changes.

•The keys on the keyboard are defined by the software, thus allowing Apple to change the keyboard easily to accommodate the special characters needed by some languages. In addition, Apple has designed the Mac so that two keyboards (differing in only one key) can be used for all versions of the product; Apple customizes a keyboard for a given language by printing the necessary legends into the plastic keys. In addition, any Mac keyboard can produce the full Macintosh character set; the only advantage to having the keyboard for a certain language is that the keyboard layout will be more appropriate for that language.

With these innovations, the most time-consuming part of modifying the Macintosh for another country is translating and printing the documentation. Apple reports that it will be shipping the Macintosh to several foreign countries "within several months of the Mac's introduction." (Companies never seem to meet such deadlines, so expect foreign versions to be shipped before the end of 1984.)

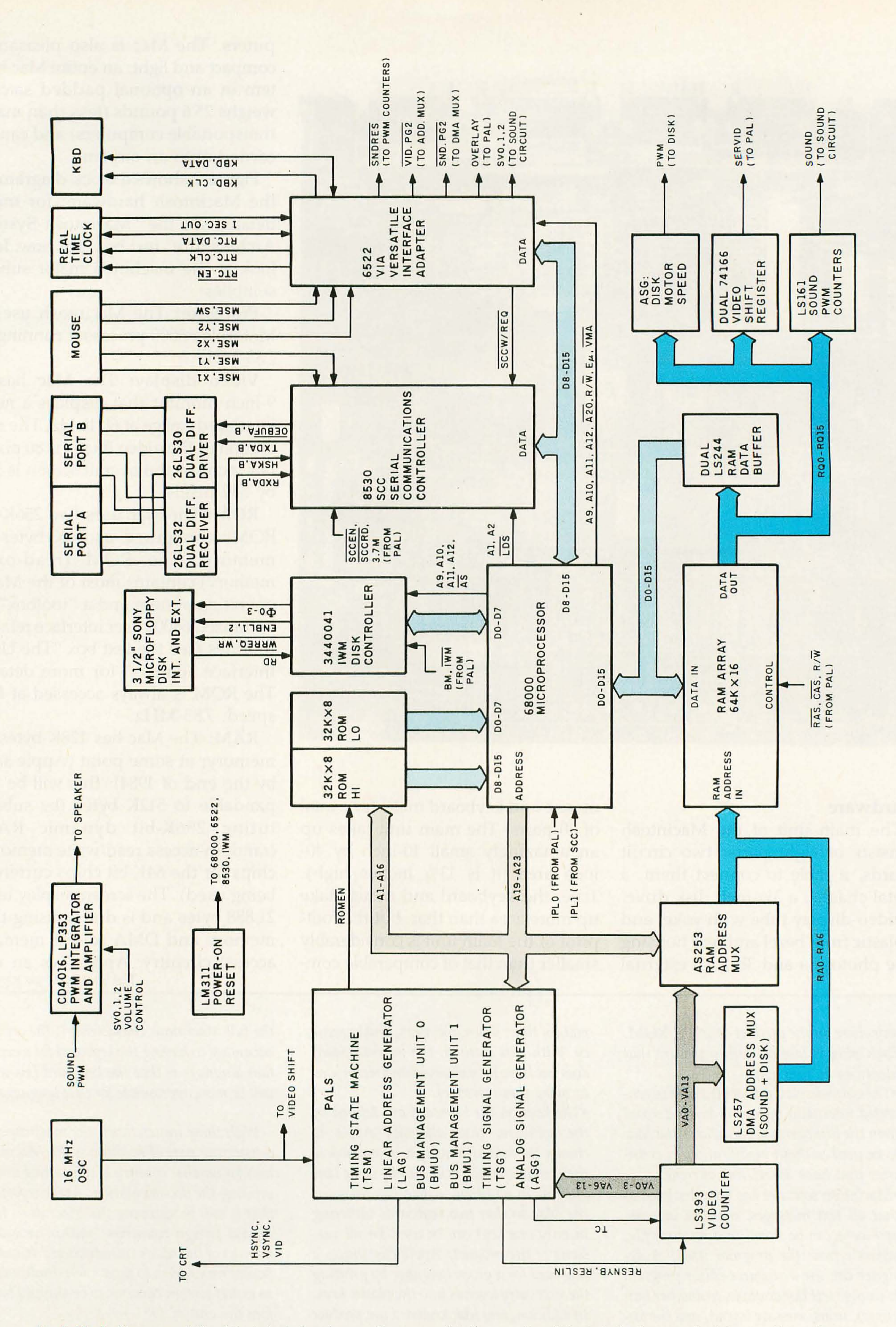


Figure 2: *A block diagram of the Macintosh hardware. For more details, see the "Macintosh System Architecture" text box.*

The User-Interface Toolbox

DESK MANAGER
DIALOG MANAGER
TEXT EDIT
CONTROL MANAGER
MENU MANAGER
WINDOW MANAGER
TOOLBOX UTILITIES
QUICKDRAW
EVENT MANAGER
FONT MANAGER
RESOURCE MANAGER

The toolbox (which occupies two-thirds of the high-speed 64K-byte ROM inside the Macintosh) includes optimized 68000 machine-language routines that handle all aspects of the Macintosh user interface—things like windows, text, the mouse, pull-down menus, desk accessories, dialogue boxes, and fonts. The figure below shows the relative relationships among the different units *(or packages of routines). Here is a brief description of each unit, starting with the lowest-level unit and working up:*

•**Resource Manager:** *These routines coordinate the use of resources, which are data structures such as text strings, menus, and icon and font definitions. These resources are kept separate from the actual code of an application, which means that the resources of an application can be modified without forcing a recompilation (or modification) of the application program. The Resource Manager is usually called by higher units like the menu and font managers.*

•**Font Manager:** *This unit supports the use of various text fonts. It calls the resource manager when it needs to use a font not already in memory, and it is usually called by the Quickdraw unit.*

•**Quickdraw:** *Quickdraw is a graphics package that is at the heart of both the Lisa and Macintosh computers. Bill Atkinson, its creator, worked for 3½ years on the code, rewriting it many times and reducing it from a 160K-byte compiled Pascal program to a 24K-byte package of highly optimized 68000 code. Atkinson, who was involved in the early design of the Lisa's user interface, designed and optimized Quickdraw for the Lisa computer; he later joined the Macintosh design team. Quickdraw is very fast—for example, it can print to the screen more than 7000 characters per second. Two of its most interesting capabilities are its ability to fill in any arbitrary shape with a pattern and its ability to "clip" an image to correspond to the boundaries of an arbitrary masking shape. The latter ability is needed to correctly display window contents when one window overlaps others. The source code for Quickdraw is identical in both the Lisa and the Macintosh.*

•**Event Manager:** *All system events (e.g., keypresses and mouse button presses) are received and interpreted through this unit, which mediates between the application program and the outside world.*

•**Toolbox Utilities:** *These routines handle miscellaneous tasks that include string operations, fixed-point arithmetic, and bitwise logical operations.*

•**Window Manager:** *Since all action on the Macintosh display occurs within windows, this is a very important unit that is used a lot. The Window Manager allows the application program to interact with windows on a high level while it takes care of the low-level details automatically. It allows you to create different kinds of boxes (document, dialogue, and alert boxes, for example), delete them, move them, change their size, and make an inactive window active and vice versa. The Window Manager ensures that the computer automatically redraws the necessary screen areas when some aspect of a window is changed.*

•**Control Manager:** *This unit controls the use of software buttons, check boxes, and dials, all of which can be called on to show and alter the status of certain variables.*

•**Menu Manager:** *Given a two-dimensional matrix of menu items (each column is a menu title followed by its selections), this unit controls the display and behavior of that matrix of pull-down menus.*

•**Text Edit:** *These routines control elementary text entry and editing. Text Edit is designed with lots of software "hooks" so that you can modify its behavior but still use it. An external unit called Core Edit, which must be loaded into RAM, contains more sophisticated entry and editing routines; Core Edit can handle different fonts, sizes, and text styles.*

•**Dialog Manager:** *Dialogue boxes are text boxes with several check boxes; usually, clicking the mouse button near a box selects it (and the action or condition associated with it) and unselects the previously checked box. An alert box (as in figure 1h) alerts you to a potentially dangerous situation and forces you to click on one of two buttons, "Cancel" or "OK." The Dialog Manager handles the display of and user response to a dialogue or alert box.*

•**Desk Manager:** *This unit allows the application program to use the desk accessories, which are resources that are called in from disk if they are not currently in memory.*

Applications can be written in Mac BASIC, Mac Pascal, or 68000 assembly language (usually one of the latter two). Both Mac Pascal and Mac BASIC are designed so that their keywords directly call most of the toolbox routines. Most applications that use the routines are essentially an endlessly repeating loop that waits for an event, determines what kind of event it is, and then processes the event.

Macintosh System Software Overview

by Andy Hertzfeld

The Macintosh is more than a powerful, inexpensive 68000-based desktop computer. It comes with a built-in personality provided by 64K bytes of handcrafted system software contained in two ROM chips on its digital board. Besides performing traditional operating-system functions such as memory and file management, the Macintosh ROM includes the revolutionary Quickdraw package and a User-Interface Toolbox to help programmers develop applications that share a consistent, advanced user interface.

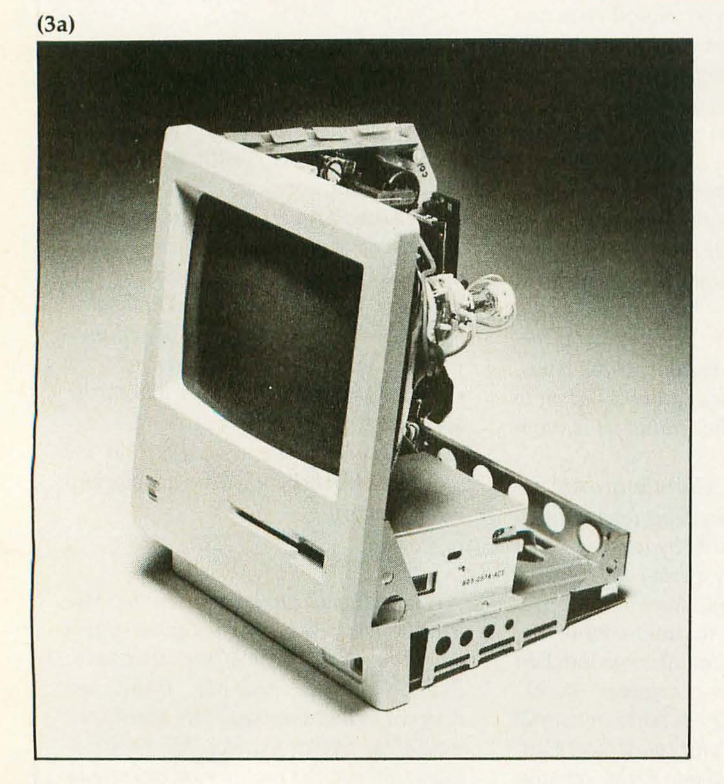
The Macintosh ROM can be thought of as an extension to the 68000 instruction set, augmenting its 56 basic instructions with more than 480 new instructions designed for implementing fast mouse-based applications. It is implemented entirely in 68000 assembly-language code that has been handcrafted and optimized over a period of almost three years. We chose assembly language over a higher-level language because it was very important for the system to be small and fast. The Macintosh is intended to be a very high-volume product, and we could afford to lavish time and attention on every routine, making each one as efficient as possible, knowing that our efforts would be multiplied by the millions of units that we will eventually ship.

It is somewhat risky to put 64K bytes of intricate system software in ROM on a disk-based system, but we did it because we wanted the machine to have a built-in standard user interface. By using our ROM-based toolbox, a programmer saves development time and precious memory space; this provides a positive incentive for doing it our way. Also, the price per bit of ROM is significantly less than that of RAM, and not having the operating system load in from disk saves space on every disk you have. Application programs never reference the ROM directly; instead, they use compact "trap" instructions that are interpreted by the system dispatcher. This allows us to intercept any routine to fix the program bugs that will inevitably arise.

The Mac's system software design philosophy emphasizes simplicity, flexibility, and high performance. We chose the single-application-at-a-time philosophy to help keep things relatively simple. The user-interface software is designed to be flexible because we are still learning how to make systems easier and more fun to use. Another reason for designing the software this way is that trying to live for years with what we thought was best at any given time would doom us to eventual failure. High performance is extremely important in an interactive system; people won't enjoy using a system unless it is very responsive.

About one-third of the ROM is devoted to what we call the Macintosh Operating System, which contains many components found in more traditional systems. It includes the low-level device drivers and interrupt handlers, an asynchronous I/O system, a memory manager, a simple, fast file system, a segment loader, and various utility routines. The I/O system supports swappable, RAM-based device drivers as well as its built-in serial, disk, and sound drivers. Most I/O and file-system calls can be made asynchronously, which allows an application to overlap I/O tasks with other tasks. The memory manager minimizes the fragmentation of available memory into small pieces by supporting relocatable objects that are always accessed indirectly; the memory manager also provides an automatic caching scheme by optionally

(3a)



(3b)

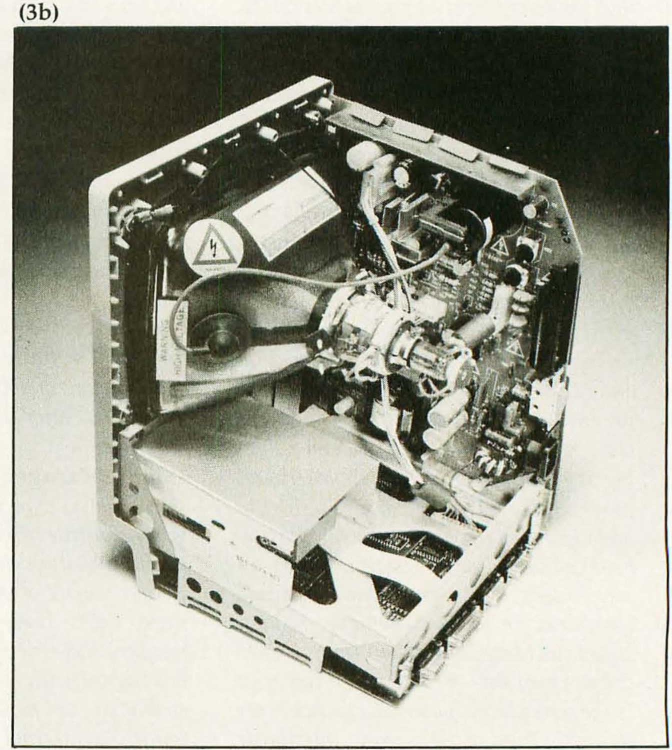


Photo 3: *Inside the Macintosh computer. From the front (photo 3a), you can see the video display and the 3½-inch disk drive. From the rear (photo 3b), you can see the two main circuit boards (right and bottom), the rear of the video-display tube, the 3½-inch disk drive, and a row of connectors at the bottom of the unit. The connections go, from left to right, to the mouse, a second disk drive, two peripherals (these are two serial ports), and an external amplifier (for sound output).*

purging objects as memory grows fuller. The file system ensures against loss of data by maintaining tags on every block; these allow the contents of a disk to be pieced back together even if the directory is destroyed.

Another third of the ROM is occupied by Bill Atkinson's Quickdraw graphics package. Quickdraw, which is the cornerstone of Apple's "Lisa technology," is responsible for the Mac's extremely fast user interaction. It draws practically everything you see on the screen, including text (in a variety of typefaces and styles) and both filled and unfilled rectangles, lines, and ovals. It also is capable of representing arbitrary areas of the screen called regions *in a very compact data structure. All Quickdraw calls are clipped to the intersection of up to three regions, providing the fundamental capability necessary for overlapping windows. Quickdraw also is capable of recording any sequence of procedure calls and saving them as a* picture. *Pictures provide an easy, powerful method for transferring graphics between applications.*

The final third of the Macintosh ROM is occupied by the User-Interface Toolbox, a collection of various managers and services intended to help a programmer develop applications that conform to the Macintosh standard user interface. Its principal components are resources, windows, menus, controls, dialogues, and a text-editing package. The window, menu, and control managers contain little information on how individual windows, menus, or controls look or behave. Instead, this information is encapsulated in definition functions, *which are kept as resources and swapped into memory as necessary to implement messages sent by the various managers. This provides a very flexible structure capable of evolving as we learn how to improve the user interface.*

Another important goal of the Macintosh system software is to facilitate the passing of data between applications. A scrap manager *is provided to help applications share data. It defines two data types that every application is requested to support (simple ASCII text and Quickdraw pictures) and lets applications define their own custom types. It provides routines for transferring data in and out of the scrap.*

As stated above, Macintosh supports only one application running at any given time. This restriction is mainly due to limited available memory. By making a few simple calls to the desk manager, an application may allow many useful mini-applications to run concurrently with itself. These small programs are called desk accessories *and are capable of cutting and pasting data with each other as well as with the major application. We currently provide five desk accessories (calculator, clock, notepad, control panel for default system parameters, and scrapbook).*

By the spring of 1983, it became apparent that we would not be able to fit all the routines that we had hoped to into our 64K-byte ROM space. We designed a facility to allow some system code (in the system resource file) to be swapped in from disk to RAM when needed. We now use five such RAM-based packages, including a fully IEEE-standard floating-point numeric package, a standard file dialogue package, and an international string package that deals with various formats for date and time display.

In summary, the 64K bytes of ROM-based firmware provide Macintosh with a unique personality and user interface, forming the foundation for the development of communicating applications that share a common user interface. The Macintosh firmware is very fast and flexible, and it will be exciting to see all the applications that develop from it in the years to come.

Andy Hertzfeld is a member of the Apple Macintosh design team.

Text continued from page 35:

disclosed proprietary technique for phase-locking the 68000 to less expensive memory, which lowers the product cost without sacrificing the speed of memory access.

When the Mac is drawing a horizontal line of the video display, the 68000 and the video DMA circuitry alternate (interleave) their accesses to the RAM address and data lines. Since these two can never access RAM simultaneously, the 68000 can never produce hashing or other glitches in the video display by accessing RAM at the wrong time. Because of this interleaving, the 68000 accesses RAM at 3.92 MHz, half of the full 7.83 MHz rate, during the display of a horizontal line of the screen. This is done in the following way: the DMA circuitry puts a word from RAM into the video shift register; while the register is sending out those 16 bits serially to the screen, the 68000 uses RAM for its own purposes; then the cycle begins again with the DMA circuitry.

When the video display is doing a horizontal or vertical retrace, however, the 68000 gets exclusive use of the RAM at its full speed, 7.83 MHz. This has a significant effect on the average speed of RAM access. Out of the 45 μs (microseconds) for each horizontal display line, over 12 μs (about 27 percent of the time) are occupied by horizontal retrace. Of these 12 μs, about 0.5 μs is used to send data to the sound and disk-speed circuitry, while the rest is available to the 68000. Furthermore, out of the 16.626 ms (milliseconds) used to draw each complete screen, 1.258 ms (about 7.6 percent of the time) are devoted to vertical retrace. Of this, about 14 μs are used for sound and disk-speed control (representing the control work done at the end of the equivalent of 28 unused horizontal lines of video), leaving more than 1.244 ms for the 68000 to access RAM at full speed.

To summarize, the ROM is always accessed at 7.83 MHz, regardless of screen display. The RAM is accessed at 3.92 MHz during screen display and at 7.83 MHz otherwise. The average speed of the system is around 6 MHz.

One memory area of interest is the *sound buffer*. Along with associated hardware, this buffer enables you to create four channels of arbitrary sound while using no more than 50 percent of the 68000's computing power. The 68000 performs look-up operations every 44 μs on up to four 256-byte waveform tables; the result of these lookups is placed in a 370-byte sound buffer, from which the sound hardware fetches 1 byte every 44 μs to deliver to an 8-bit digital-to-analog circuit (DAC). An internal VIA (versatile interface adapter) can also be used to generate a single square-wave tone while using an insignificant part of the 68000's computing power.

Mass storage: The Macintosh uses a custom version of the Sony 3½-inch disk and drive (see photo 4). The

The Macintosh Memory Map

The Macintosh memory map contains RAM, ROM, and I/O devices that communicate with the 68000 through specified memory locations. When the Macintosh is turned on (i.e., at boot-up), the 64K-byte ROM maps into the first page of memory and is used to get the system started. After boot-up, the positions of RAM and ROM are changed so that the 128K-byte block of RAM occupies the first two pages of memory (see figure below).

The Phase Read area of memory is used to determine whether the computer's timing signals are correctly in phase with each other; this is usually done by ROM routines at boot-up.

The VIA (versatile interface adapter) locations are used by the Macintosh's 6522 VIA. This chip gives the Macintosh parallel input, output, and interrupt lines, shift registers, mouse information, and clocks.

The IWM locations are used by the Macintosh's IWM (integrated Woz machine), which controls all access to the internal 3½-inch disk drive and the optional external one.

The SCC Read and SCC Write locations are used for several purposes. They allow the SCC (serial communications controller) chip to handle two serial ports at rates between 30 and 230,400 bits per second. In addition, they allow the SCC to detect mouse motion (in conjunction with the VIA) and adjust the phase of the Macintosh timing signals.

Most programmers will not need intimate knowledge of the Macintosh memory map. The 64K-byte ROM contains sophisticated routines that take care of low-level processes like I/O, memory management, video display, and similar tasks. Apple encourages the use of these routines; they mean less development time, conformity to the standard Macintosh user interface, faster programs (ROM always runs at full speed), and more memory space for programs and disks.

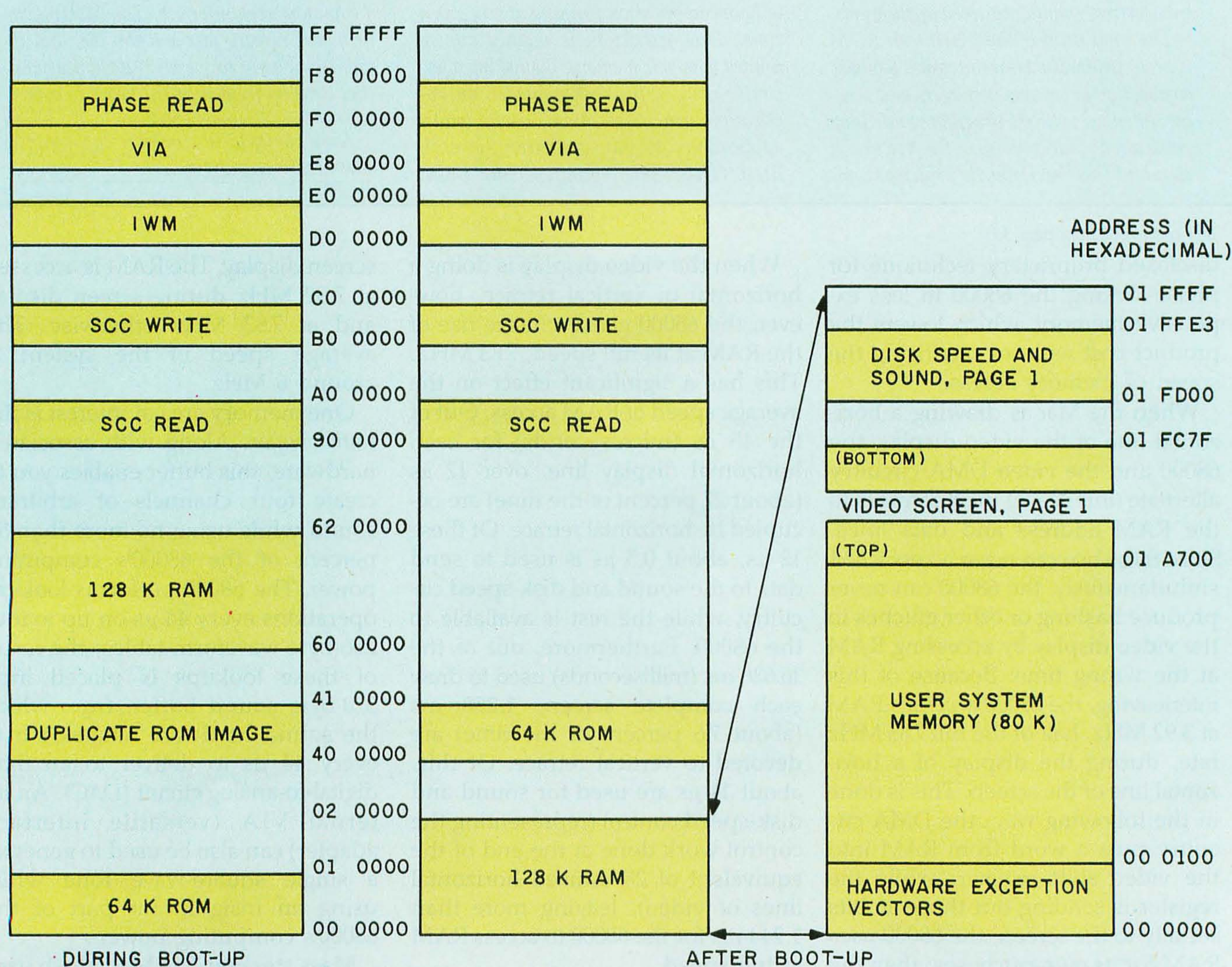




Photo 4: *The Sony 3½-inch disk is encased in a rigid plastic housing, and the oval window through which the magnetic medium is accessed is protected by a metal shutter that slides out of the way when the disk is inserted in the drive. These factors help protect the disk from casual use.*

drive can store 400K bytes on a single-sided 3½-inch disk; the Mac is designed to be able to use double-sided drives to get 800K bytes per disk, an option that Apple may pursue at a later date. The standard Sony 3½-inch disk (used to date by Hewlett-Packard and other vendors) puts 70 tracks of data at 135 tpi (tracks per inch) onto each disk. At Apple's urging, Sony now makes the drive in another model that has 80 tracks of data at 135 tpi. As a comparison, the Hewlett-Packard HP 150 uses the 70-track version and conventional sectoring to get 270K bytes per single-sided disk.

Sharing Data among Programs

Macintosh programs, if they are designed in accordance with Apple guidelines, will be able to trade data among themselves without one program having to know anything about the nature of the others. This is done through use of a shared memory area called the clipboard *and the standardization of the data that can be stored in it.*

The clipboard is a relocatable piece of memory that is not erased when a new program replaces an older one. It is used as follows: the first program copies data into the clipboard, the second program replaces the first with its own code and data, and the data in the clipboard is added to the data now in memory. The clipboard can contain a variable number of data items, though every item must be of a different type. Each data item consists of a four-character data-type identifier, a 32-bit length (in bytes), and a stream of bytes that makes up the actual contents of the data item.

Programs are free to implement their own data types. Apple has defined two—text and Quickdraw pictures—and encourages every program to be able to read both and write at least one of these data types. Text is a simple ASCII string of characters without any information on the size, font, or position of the text. Quickdraw pictures are defined as a sequence of commands that can be understood by the Quickdraw routines. A Quickdraw picture can contain displayable text (which does include information on text size, font, and position on the screen), a sequence of elementary graphics commands that will recreate the image, or the image described as a stream of bits. These two data types provide a guaranteed means of communication among Macintosh programs.

In addition to the change to 80 tpi, Apple contracted Sony to modify the drive in several other ways. Two changes allow the Sony drive to mimic the behavior of the Lisa "twiggy" drives (which were originally chosen for use in the Mac): disk ejection under software control and variable disk-rotation speed. The first change allows the Mac to ensure that a disk is correctly updated before it is surrendered to the user (that is, you can't take a disk out of the drive until the Mac software permits it). The second change enables the Mac to record onto the disk at a constant linear density (which means you can put more data on the outermost tracks), as opposed to the constant radial density approach most computers use (which puts the same amount of data on each track regardless of position).

The Macintosh's drive rotates under software control between 390 and 600 rpm (revolutions per minute) and transfers data at the rate of 489.6K bits per second (bits as recorded on the disk, not decoded data bits). Most computers use a disk-controller chip instead of the processor to control the drive. The Mac (like the Apple II) uses its processor to directly control the drive. Because the Macintosh can control more disk-related parameters than the Apple II (the variable motor speed, for example), Macintosh owners will be treated to an even greater wealth of copy-protection schemes than Apple II owners enjoy. Also, the Macintosh drive uses *modified group code recording* to encode data onto the disk. This technique, invented by Steve Wozniak for use with the Apple II, encodes 6 bits of data into an eight-transition group that is recorded onto the disk surface.

Keyboard: The keyboard has 58 keys; the left Shift key is split on the international version of the Macintosh, giving it a total of 59 keys. The keyboard includes Return, Caps Lock, and Shift keys in their usual places, two Option keys, and a cloverleaf command key (see photo 5). Combinations of the Shift, Caps Lock, and Option keys give each key up to six meanings; the command key

acts as a modifier and is often used with a letter key as the keyboard substitute for a mouse-selected menu item. The keyboard contains an 8021 microprocessor and is connected to the main box by a four-wire bidirectional serial connection. The connections on both ends use the same kind of square modular plug found in most telephones.

Mouse: The Mac's one-button mechanical mouse, about the size of a pack of cigarettes, is essentially the same as the Lisa's; it differs only in the shape of the plastic housing. The mouse is used to position the cursor on the screen; when you slide the mouse over a horizontal surface, the cursor moves in the same direction on the screen.

Serial bus: The Macintosh's serial bus is very important because it is the way that most future peripherals (except the second 3½-inch disk drive and the keypad) will connect to the computer. The bus can run in two modes: with an external clock, it can transfer data at up to 1 megabit per second; with internal clocking (which embeds clock bits in the data stream itself), it can transfer data at up to 230.4K bits per second. The latter scheme will be used to connect most peripherals, which need only a low to medium data-transfer rate, to the Macintosh in a passive daisy-chained line. This scheme implements what the Mac's designers call "virtual slots."

Virtual slots have several advantages over conventional hardware peripheral slots. They reduce the potential problems inherent in any added mechanical connection (a serial interface connector has fewer pins than a typical interface board). They reduce RFI (radio-frequency interference) by keeping the main box leakproof and allowing easy, inexpensive shielding of the serial line. By deciding that peripherals will supply their own power, the Macintosh designers were able to streamline the power supply of the main box without worrying about the power needs of unspecified future peripherals. Finally, virtual slots eliminate the need of peripheral cards to insert themselves somewhere in the computer's memory map; the unchanging memory map creates a known, unchanging system architecture that all software designers can be assured of, regardless of the peripherals connected.

The virtual-slot scheme is both practical and elegant; it offers a simple, standard way to connect unspecified future peripherals. The 230.4K bit-per-second data-transfer rate is high enough to meet the needs of most peripherals—printers, modems, plotters, music synthesizers, and so on. However, one class of add-on card will not work using this scheme: processor cards like the Microsoft Softcard, which allow a computer to run another processor's software. Such cards require full access to the data and address lines and will not work via a serial "virtual slot." As a result, despite some rumors to the contrary, the Macintosh will never use IBM PC- or MS-DOS-based software.

Power supply: Apple designed two power supplies for the Macintosh. The first one uses a 60-watt switching power supply similar to one used in the Apple II family; it can operate on 85 to 135 V AC at either 50 or 60 Hz. For technical reasons, use of this power supply would have delayed the introduction of the machine, so Apple designed and produced a simpler nonswitching power supply



Photo 5: *The Macintosh keyboard.*

(105 to 130 V AC, 60 Hz) for initial use in the first U.S. models of the Macintosh. The first switching power supply will be used later in the year for the international model and possibly for the U.S. model.

The supply was designed to drive two twiggy disks; when the design was changed to include two 3½-inch disks instead, the supply had a sizable margin of unused power.

System Software

As stated before, the Macintosh contains 64K bytes of ROM accessed at 7.83 MHz. The ROM contains most of the Mac operating system and a set of optimized 68000 routines called the Macintosh User-Interface Toolbox. The operating-system software interacts at the lowest level with the hardware; it includes such things as device drivers and memory- and file-management routines. The toolbox contains various routines that let you manipulate windows, text, the mouse, pull-down menus, desk accessories, dialogue boxes, fonts, and other aspects of the Mac user interface. These are high-level routines that perform the details of such complicated operations with minimum programming on the application designer's part. For example, the window-management routines take care of correctly redrawing the display when a window is moved or changed. For more details, see the text box "The User-Interface Toolbox."

The designers intend for you to access all ROM routines indirectly via the 68000 "line 1010 unimplemented" instructions, which receive their addresses from a table in RAM; this table can be changed to point to other routines, thereby allowing future versions of Mac software to patch the inevitable bugs that will be found in the Mac ROM. Because the application drives the ROM routines (instead of the other way around), the Macintosh is an "open" system whose behavior is completely determined by the contents of the disk inserted into it—that is, software designers can use the ROM routines to create a "standard" Macintosh application, or they can write their own code to create an application that behaves the way they want it to.

Although the designers of the Macintosh have a general philosophy of allowing only one application program to be open at a time, they have included in the main menu a collection of short, useful programs that can run without forcing you to end your current program. Apple calls these programs *desk accessories*. Many of the accessories are simply conveniences—the clock accessory, for example, shows you the current date and time—but a very powerful accessory is called the *scrapbook*. Ordinarily, you can cut and paste data from one document to another by cutting the data into the clipboard, loading in the new document, and pasting in the data; this process would be tedious if you had several items of the same type to cut and paste. The scrapbook is a sequence of data items—text or graphics—that can be stored or recalled together, thus minimizing the number of document changes and allowing you to recall often-used data items easily. The scrapbook is actually implemented as a disk file; as a result, it

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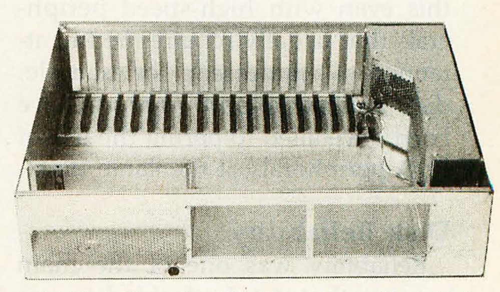
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tends to be rather large.

System software reacts to all peripherals on an asynchronous basis—peripherals compete for the attention of the 68000 by sending it interrupts, which the 68000 services according to the level of the interrupt. This keeps the 68000 from being tied exclusively to a peripheral—for example, to the 3½-inch disk drive waiting to get up to its full speed—when it could be doing something more useful. The Mac's designers have managed to do this even with high-speed peripherals that usually require the full attention of a processor. For example, disk and serial-port routines have been dovetailed to permit the use of both peripherals at the same time.

Disk Reliability

Reliability was one of the main reasons that Apple decided to use the 3½-inch Sony disk drive instead of the 5¼-inch twiggy drive. (A projected shortage of twiggy drives was another reason.) Apple is expecting the Macintosh to be the first real consumer-oriented computer, and it sees the magnetic medium as being more likely to fail than the electronics. The Sony 3½-inch disk is better suited to the consumer environment. The drive can hold an acceptable amount of storage per disk, and the small disk, with its rigid shell and normally closed access window, is less likely to suffer from bad handling than a conventional 5¼-inch floppy disk. In addition, the magnetic medium is connected to a steel hub that the drive mates with and rotates. This is an improvement over 5¼-inch floppy-disk drives, which clamp the Mylar edge of the center hole. The 3½-inch disk hub is needed to get accurate enough disk-head placement to make a data density of 135 tracks per inch possible.

The data on the disk is encoded in a way that enables the Macintosh to recover from some disk medium or disk file errors. The file directory is duplicated in a normal disk file (which can be used if, for some reason, the directory is damaged). Also, each block of data on the disk includes a 12-byte identifier that gives the file number, sequence-within-file number, and date/time stamp for the data in the rest of that block; this can be used in many situations to recover most or all of the data on the disk.

Applications and Languages

Neither application software nor a language is included in the basic Macintosh package. However, a two-program set will be available for $195; both programs require the recently introduced Imagewriter printer to print things out. The first program is Mac Paint, the drawing program we looked at earlier. Created in house at Apple, Mac Paint is limited to drawings that will fit on one 8½- by 11-inch page. Mac Paint is unlike the Lisa drawing program (Lisa Draw) in that it manipulates the drawing on a bit-by-bit level (a Lisa Draw drawing is stored as a collection of elementary objects—circles, text, boxes, etc.). This representation makes some things, such as arbitrary erasures, easier on the Mac and other things, such as deleting a single object within the drawing, harder.

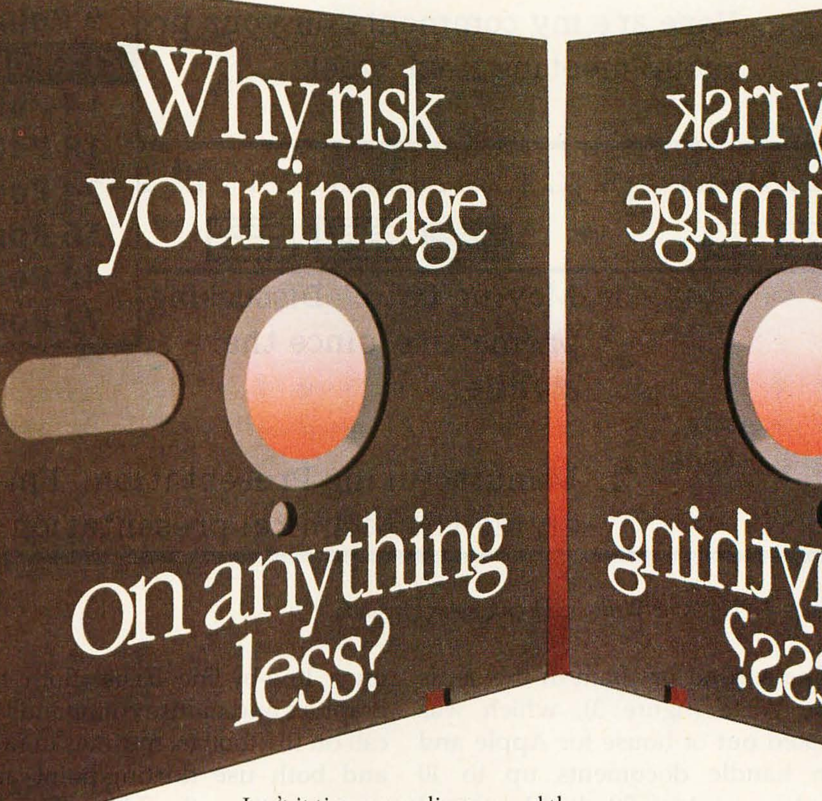
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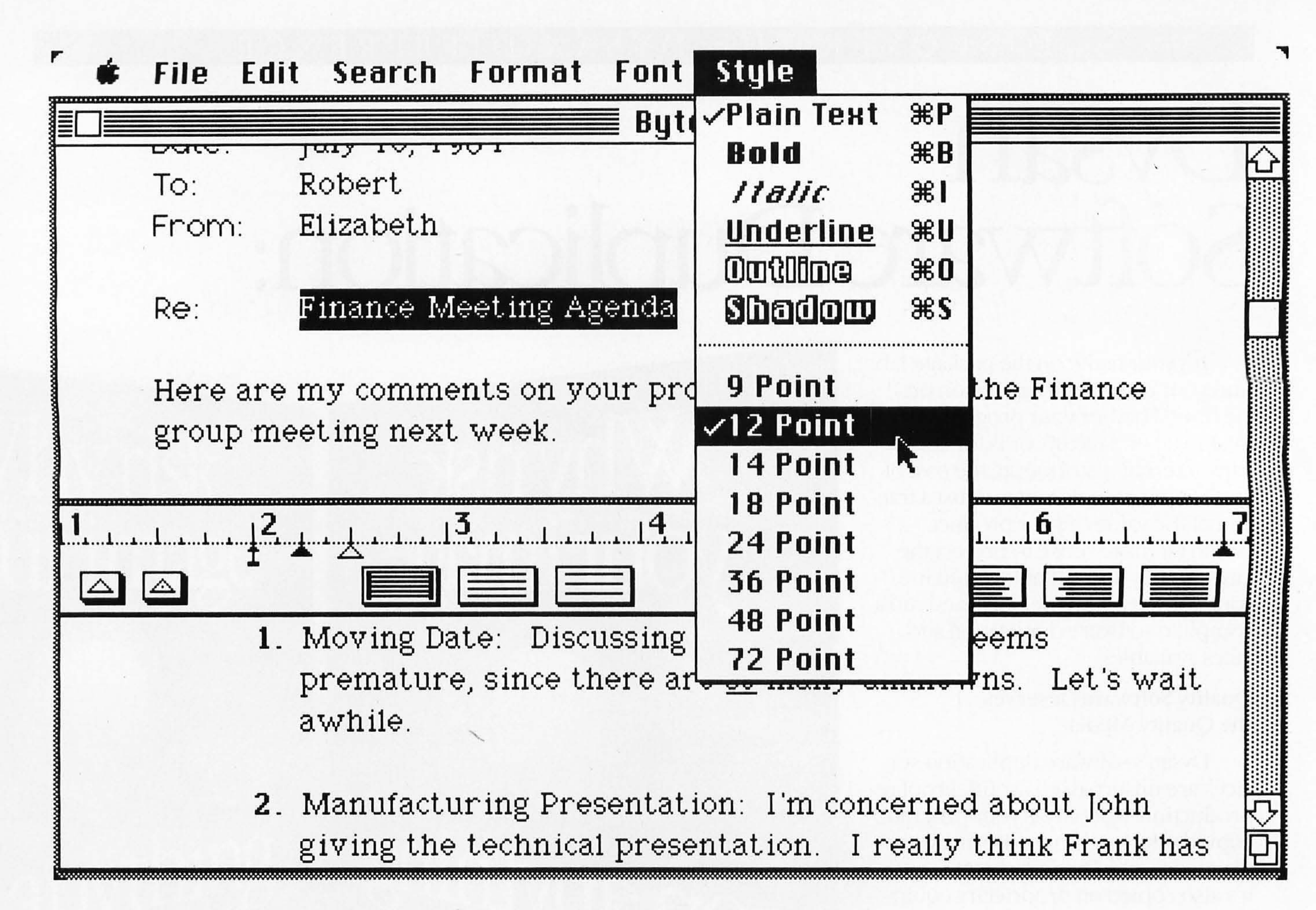


Figure 3: *The Mac Write word-processing program.*

The second program in the set is Mac Write (figure 3), which was created out of house for Apple and can handle documents up to 10 single-spaced or 20 double-spaced pages. Like Lisa Write, Mac Write can handle multiple fonts and sizes as well as variations achieved by adding any *combination* of five modifiers—underline, bold, italic, outline, and shadow.

Apple Macintosh Pascal, Assembler/Debugger, BASIC, and Logo will cost $99 each; the first two will be available during the second quarter of 1984, and the other two will follow in the third quarter. The Logo is from LCSI, which developed Apple II Logo. Both the BASIC and Pascal compile on a line-by-line basis into an intermediate pseudocode, which gives them the speed of compiled languages while retaining the interactive nature of interpreted languages. Both languages use separate windows for program source code and output, and both can be debugged on a line-by-line basis. Both have graphics and mouse commands that call on the toolbox routines in ROM, and both use floating-point arithmetic routines (in RAM) that meet the IEEE-754 floating-point standard.

Mac Pascal, which was created out of house, is interesting in that it is the only Pascal I know of that can be executed interactively. Another nice feature is its syntax checker, an item that can be called from its "Run" menu. This menu item is often handy for finding those petty syntax errors to which Pascal code is prone.

Mac BASIC was created in house by Donn Denman, who worked on Apple III Business BASIC. An interactive, multitasking BASIC, it can execute multiple copies of the same program or multiple programs simultaneously; each program and each running task has its own window.

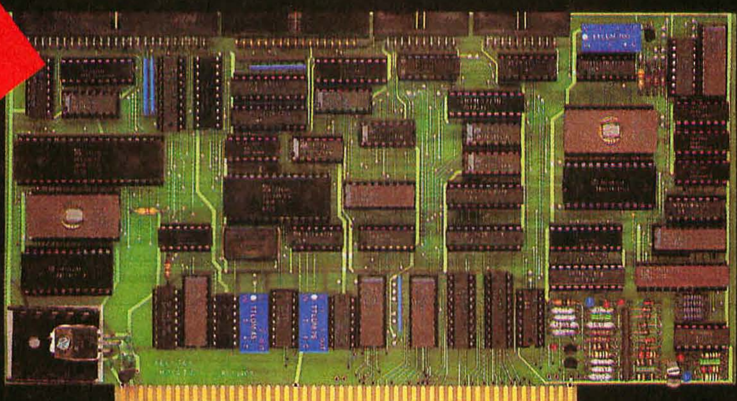
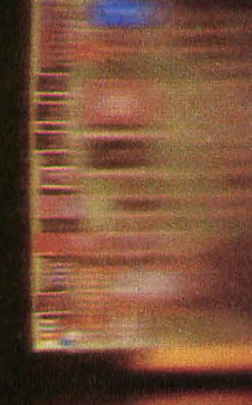
Other Apple programs announced for delivery in 1984 include Mac Terminal (which emulates the DEC VT-52 and VT-100 and Teletype ASR33 terminals—available first quarter, $99). Also planned are Mac Draw (an object-oriented drawing program) and Mac Project (a scheduling and project-management program). These are both Macintosh versions of two Lisa application programs; each costs $125 and will be available in the third quarter of 1984.

Third-Party Software

Apple has not spent all its energy trying to write all the software that the Macintosh needs. Instead, it has created two exemplary Macintosh packages and gone to third-party software developers to get *them* to create the bulk of available Macintosh software. Apple estimates that by the time you read this, the Mac will be in the hands of more than 100 software vendors.

At the time this was written, some software developers had made commitments to market Macintosh software. Microsoft Multiplan and BASIC will be available at the Mac's

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- Individual software reset capability.
- Conforms to the proposed IEEE-696 S-100 standard.
- Controller can accommodate two rigid-disk drives and one cartridge tape drive. Expansion is made possible with an external card.

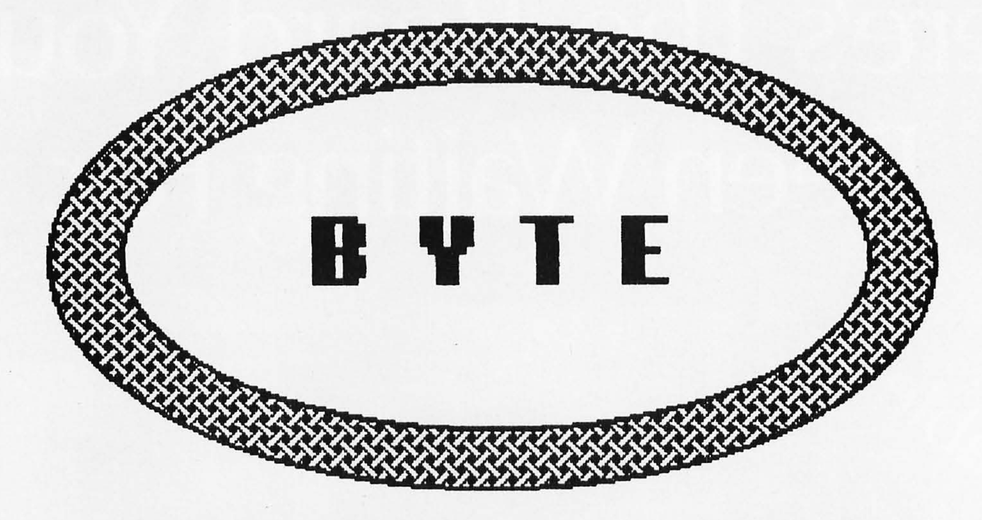
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Listing 1: *Graphics (listing 1a) and text (listings 1b and 1c) as printed by the Macintosh and the Imagewriter printer. The text shown in listings 1b and 1c is representative only; some of the fonts shown may not be included with Mac Write or may have different names. Listing 1b is text printed out in high-resolution mode; listing 1c shows the same text printed out in medium-resolution mode. These print samples are reproduced at the same size as the originals.*

(1a)



The Small Systems Journal

(1b)

This is 9-point Rosemont
This is 12-point Old English
This is 12-point City
This is 12-point Overbrook
This is 12-point System
This is 12-point Rosemont
This is 12-point Ardmore
This is 12-point Merion
This is 12-point variants:
-- Rosemont bold
--Rosemont italic
--Rosemont underline
--Rosemont outline
--Rosemont shadow
--Rosemont out-
line shadow
bold
These are size variants:
--14-point
--18-point
--24-point
-36-pt.

(1c)

This is 9-point Rosemont
This is 12-point Old English
This is 12-point City
This is 12-point Overbrook
This is 12-point System
This is 12-point Rosemont
This is 12-point Ardmore
This is 12-point Merion
This is 12-point variants:
-- Rosemont bold
--Rosemont italic
--Rosemont underline
--Rosemont outline
--Rosemont shadow
--Rosemont out-
line shadow
bold
These are size variants:
--14-point
--18-point
--24-point
-36-pt.

By the Way. . .

•No, we didn't misspell the name. "McIntosh" is the apple, but "Macintosh" is the Apple computer. The product's original code name was misspelled by its first users, and Apple decided to stay with that spelling.
•The Mac Write program was originally named "Macauthor," and the Mac Draw program was originally named "Mackelangelo." People at Apple decided that the names were too cute to use; they were right.
•Apple is one of those exceptional companies that gives its employees credit instead of commanding them to work in anonymity behind the corporate name. The names of the hundred or so employees who worked on the Macintosh are molded into the inside face of the plastic rear housing. Don't try to look for them, though; the Mac is not supposed to be opened except by repair people.
•The Macintosh is not going to be strictly a "serious" computer. Some of the software engineers at Apple are very excited about the great games that could take advantage of the Mac's computing power and high-resolution graphics. I saw an incredible game that has Alice (of Wonderland fame) dodging animated chess pieces in 3D.

introduction; Microsoft File, Chart, and Word will be available by mid-February. Lotus is working on converting its popular 1-2-3 spreadsheet program. Software Publishing Corporation will have its PFS File and PFS Report programs available sometime in April.

Optional Hardware

The Macintosh uses Apple's new $495 dot-matrix Imagewriter printer, the only printer that is supported by the current print driver within the Macintosh. To get its level of graphics and text quality (see listings 1a through 1c), the Imagewriter usually stays in a graphics mode that prints a single column of dots for every byte sent to it by the Mac. However, the Imagewriter can print text in three modes: a high-resolution mode (listing 1b), a medium-resolution mode (listing 1c), and a draft mode that uses the printer's built-in character set for quick text-only printing. (I found I prefer the medium- over the high-resolution text.) Although the Imagewriter could hardly be called fast, it is not unacceptably slow, and it is considerably faster than the Apple Dot-Matrix Printer running under the Lisa computer's parallel port.

Two other pieces of hardware are an external disk drive (at $395, available during the first quarter) and a numeric keypad ($99, at introduction). The external disk driver connects to the main unit via a dedicated "second disk" connector in back. When the keypad is connected, the keyboard line runs from the Mac, through the keypad, and into the keyboard itself. Another product, announced but not scheduled, is external hardware that will give the Mac IBM 3270 emulation capability.

Documentation and Training

In its ads, Apple is stressing the necessity of going to a Macintosh dealer and trying the computer out. Once you have bought it, though, you will probably be learning how to use the Mac on your own. Apple will help you in this process by providing you with a cassette/disk combination. You boot up the 3½-inch disk tutorial and listen to the interactive lesson provided on the cassette. (Of course, you have to have a cassette player.) Although I have not seen the cassette/disk tutorial program, I think it will work well; text-only tutorial programs are fine, but many buyers of the Mac will benefit from the warmth of a human voice teaching them.

I saw final-draft copies of only two Macintosh product documents. *Explore Mac Paint* is a booklet (about 25 pages) that teaches you about Mac Paint by showing you what it does. It is very easy to read because it has more pictures in it than text. *Mac Write* is much longer and looks more like conventional documentation. It is sensibly divided into three sections: "Learning Mac Write" (a do-by-example tutorial that shows you most of the features of the program), "Using Mac Write" (a "cookbook" showing you how to accomplish many common tasks), and "Reference." All in all, the documentation should be quite good.

Service

The Macintosh has no user-serviceable parts. Unlike the Lisa computer, the Mac is *not* meant to be opened by the user; you are expected to return your Mac to an authorized Apple service center for repair. The Mac comes with Apple's standard 90-day parts-and-labor warranty. You can also buy a one-year maintenance contract. According to Apple, other service plans will be available, including options for large-volume purchasers of the Macintosh.

Caveats

I wrote this article after two days of meetings with various members of the Macintosh staff, studying preliminary Mac documentation, making numerous phone calls to Apple, and working for several days (over a period of weeks) with a Macintosh computer. I used several final-draft versions of Mac Write and Mac Paint, though I occasionally found operating-system features that "crashed" the system or weren't yet implemented. Apple was still making minor changes to both software and pricing when this was written.

Commentary

There is a lot to like about the Macintosh; it is a superb example of what American technology can do when given the chance. The simple, compact, economical design, the virtual slots, and the enhanced performance of 128K bytes of memory because of the 64K-byte ROM code are all important innovations done well.

I'm glad that Apple decided to go

with a Sony 3½-inch disk (as compared to the Lisa 1, which needs special, expensive, hard-to-get twiggy floppy disks). However, I'm disappointed that both Apple and Hewlett-Packard have used nonstandard formats that are incompatible with each other. It would have been nice to start the widespread use of the Sony microfloppy with a standard disk format, but the incentive to sacrifice standardization for performance is one of the drawbacks of a competitive industry.

I also feel strongly that the basic Macintosh package should include two disk drives. With a one-drive system, it will take at least eight disk swaps to back up a 3½-inch disk. How many people (especially novices) will go to this trouble, and how many will suffer when they don't? (I am not alone in feeling this way; the first thing two BYTE editors said when they first saw the Macintosh was, "Only one disk drive? You've got to be kidding!" After numerous disk swaps when trying to load Mac Paint from one disk and a drawing from another, I am convinced that most users will eventually buy the second disk drive.)

At the time this was written, Apple was committed to a totally unbundled pricing of the Macintosh—that is, the basic Macintosh package (at $1995 to $2495) includes the main unit, the keyboard, the mouse, necessary cables, a tutorial disk, and a disk containing the operating system. Everything else—Mac Write, Mac Print, all languages, the Imagewriter printer, and the second disk drive—is priced separately. Since manufacturers want to claim the lowest possible price for their products, unbundling is common (IBM, for example, introduced the IBM PC with a low-end model, 16K bytes of memory, and a cassette port for $1265). True, the low-end Macintosh is far more complete than most manufacturers' low-end products, but Apple has taken unbundling farther than any other microcomputer vendor—no one has sold a computer without BASIC (or some other language) in years.

A usable Macintosh system with

Mac Write, Mac Draw, a programming language, and the Imagewriter printer costs from $2589 to $3189; a second disk drive will add another $395. Apple would be wise to make this package available at a discounted package price, just as it now does for the Apple IIe. Apple contends that the Macintosh will become a home machine because office users will take it home a few times and like it enough to buy themselves one for their personal use. However, the Mac is still too expensive to penetrate the home market significantly; that will be left to less expensive machines, such as the Commodore 64, the IBM PCjr, the Apple II family, and the Coleco Adam.

Finally, I have to point out that, although Apple's advertisements call the Macintosh a 32-bit system, its MC68000 processor is generally regarded as a 16-bit processor (the limiting factor is its inability to deal with multiplicands greater than 16 bits). This is no different from the vendors of some other 68000-based microcomputers, but I hate to see Apple hyping a machine that easily stands on its own merits.

Conclusions

Exactly a year ago, in a product description of the Apple Lisa computer, I said, "Technology, while expensive to create, is much cheaper to distribute. Apple knows this machine is expensive and is also not unaware that most people would be incredibly interested in a similar but less expensive machine. We'll see what happens."

The Macintosh is still too expensive to penetrate the home market significantly; that will be left to less expensive machines.

Now we have seen what has happened, and it is rather impressive. The Lisa computer was important because it was the first commercial product to use the mouse-window-desktop environment. The Macintosh is equally important because it makes that same environment very affordable. It is also important because it is a second-generation design that, in several areas, improves on the original.

The Macintosh will have three important effects. First, like the Lisa, it will be imitated but not copied. In the year since the Lisa was announced, dozens of hardware and software companies have announced products that duplicate part of the Lisa user environment—the mouse, the windows, the integrated software. Some, like Microsoft's mouse-based series of packages and Visicorp's Visi On, have tried to mimic that environment on a smaller, less expensive machine (the IBM PC) with only partial success.

In a similar way, companies will be out to imitate the Macintosh, but their attempts will be less successful. Those companies that try to imitate

the Mac on other machines will have trouble matching its price/performance combination. So far, attempts to imitate the Lisa by enhancing an existing computer (usually an IBM PC) have been given the benefit of the doubt because they are less expensive than the Lisa; attempts to imitate the Macintosh will now have a harder time because the Mac with software is about as cheap as the host hardware alone.

The only other way to match the Mac would be to design an entirely new system that would be comparably priced. This will probably not be attempted; only a few corporations have the ability to duplicate Apple's design and manufacturing effort, and still fewer will make such a large financial commitment. (Apple is the only American company that does not live under the tyranny of next quarter's profits; if any company tries to duplicate Apple's effort, it will probably be a Japanese one.) Those that try will find it hard to create similar technology that competes with the Macintosh in size and price; Apple is confident that a number of its components and manufacturing techniques will be difficult to copy. Even though Apple has suffered from carbon-copy Apple II machines, it does not expect to have the same thing happen with the Macintosh.

Second, the Macintosh will secure the place of the Sony 3½-inch disk as the magnetic medium of choice for the next generation of personal computers. I was disappointed when I first saw that the Mac used the 3½-inch disk—"Another disk format to contend with," I thought, "and you can't use disks from the Lisa." (You *will* be able to use Mac disks with the new Lisa 2; see "Apple Announces the Lisa 2," on page 84.) Once I had heard Apple's line of reasoning, though, I had to agree with its choice. Hewlett-Packard's HP 150 is the only other major computer to use the Sony 3½-inch disk to date; Apple's use of it will tip the scales in Sony's favor, and other manufacturers will follow.

Third, the Macintosh will increase Apple's reputation in the market; in fact, to some people Apple will be as synonymous with the phrase "personal computer" as IBM is synonymous with "computer." The Mac will compete with IBM's PC, not its cheaper sibling, the IBM PCjr. Many business users will stay with the "safer" IBM PC. However, people new to computing and those who are maverick enough to see the value and promise of the Mac will favor it. The Mac will delay IBM's domination of the personal computer market.

Overall, the Macintosh is a very important machine that, in my opinion, replaces the Lisa as the most important development in computers in the last five years. The Macintosh brings us one step closer to the ideal of computer as appliance. We're not there yet—at least, not until the next set of improvements (which, in this industry, we may see fairly soon). Who knows who the next innovator will be?■

Gregg Williams is a senior editor at BYTE. *He can be reached at POB 372, Hancock, NH 03449.*



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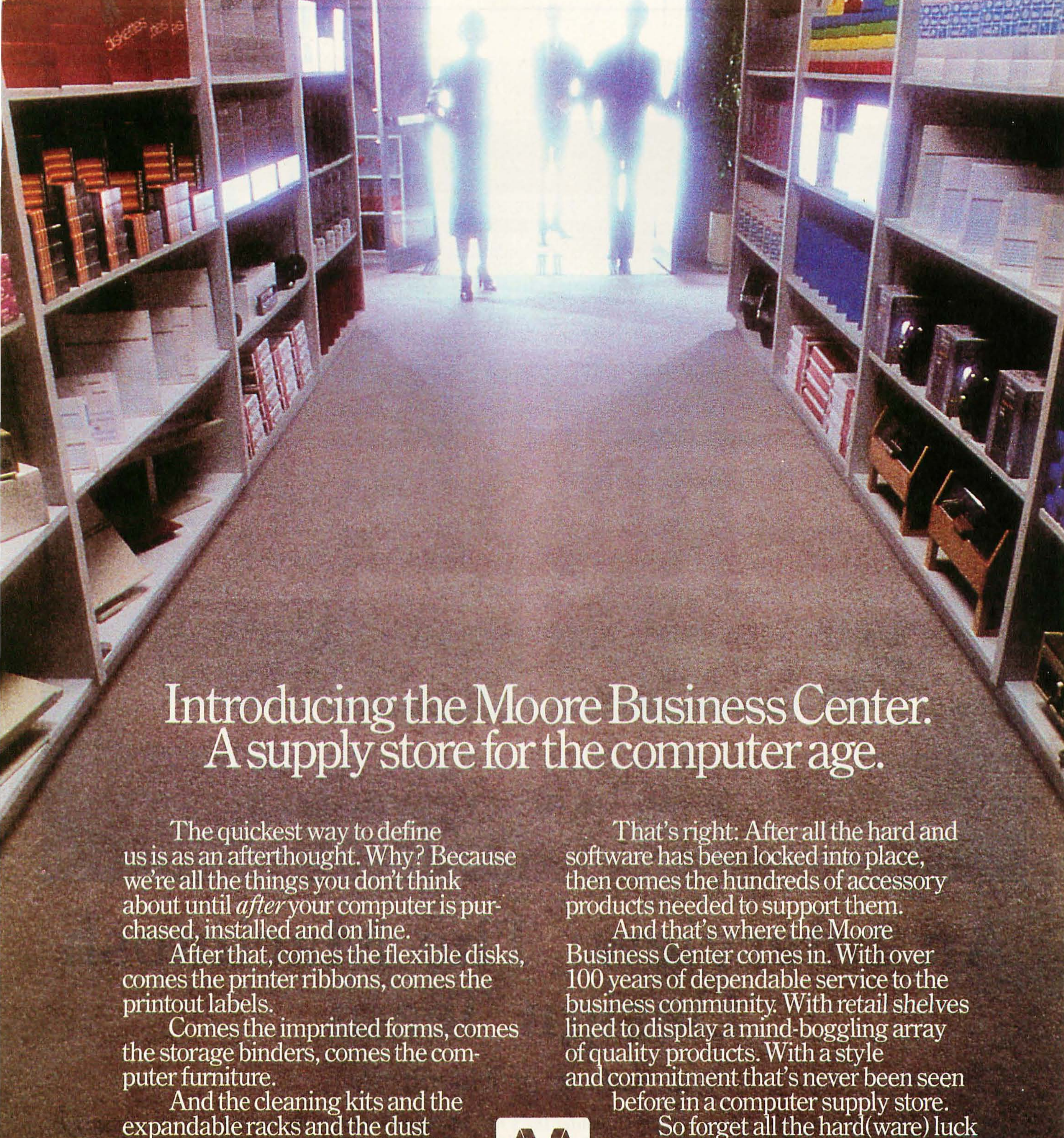
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Left to right: Andy Hertzfeld, Chris Espinosa, Joanna Hoffman, George Crowe, Bill Atkinson, Jerry Manock.

An Interview: The Macintosh Design Team

The making of Macintosh

On October 14, 1983, the design team for Apple Computer Inc.'s new Macintosh computer met with BYTE Managing Editor Phil Lemmons at the company's Cupertino, California, headquarters. In the dialogue that followed, Bill Atkinson, Steve Jobs, Andy Hertzfeld, Larry Kenyon, Joanna Hoffman, Burrell Smith, Dave Egner, Chris Espinosa, Steve Capps, Jerry Manock, Bruce Horn, and George Crowe discussed the evolution of their brainchild.

BYTE: How did the Macintosh project begin?

Jobs: What turns on Andy and Burrell and Chris and Bill and Larry and everyone else here is building something really inexpensive so that everyone can afford it. It's not very many years ago that most of us in this room couldn't have afforded a $5000 computer. We realized that we could build a supercheap computer that would run Bill Atkinson's amazing Quickdraw and have a mouse on it—in essence, build a really cheap implementation of Lisa's technology that would use some of that software technology. That's when the Macintosh as we know it was started.

Hertzfeld: That was around January of 1981.

Smith: We fooled around with some other ideas for computer design, but we realized that the 68000 was a chip that had a future and had...

Jobs: Some decent software!

Smith: And had some horsepower and enough growth potential so we could build a machine that would live and that Apple could rally around for years to come. So we looked at what the Lisa group was doing and knew that the designers were onto some really hot ideas. They have a lot of very advanced things they want to do with Lisa. Mac basically does one thing at a time as opposed to doing several things simultaneously. The memory-management unit that's critical for a Lisa application, for example, becomes something we can do without very nicely. Our real goal was to design a great system with just a bit map and based on a 68000 but also a really cheap system. Could we write incredibly great software that wouldn't chew up megabytes of memory? To do what used to take megabytes in a very tiny machine?

Atkinson: It's not like we didn't want a memory manager in it or didn't want lots of memory or didn't want hard disks. What we wanted was for lots of people to be able to own these things. We saw something beautiful that we built and we said, "How can we get this out to a lot of people?"

Espinosa: It doesn't matter how great the computer is if nobody buys it. Xerox proved that. The key thing you've got to remember is that back then, if you told anybody you could build a computer using a 68000 with anything under a hundred integrated circuits, they would have said you were crazy.

Kenyon: Most people have twice as many chips just for central processing unit support on the 68000. So nobody had ever conceived that you could build a cheap system...an Apple II chip-count system with a 68000.

Atkinson: We want the most computer that you can get for the least dollars so that the most people can have it. . . and then you can concentrate on making the world's best software for it.



Bill Atkinson.

Espinosa: And you look at this board, and every chip on there is pretty expensive. There's not a lot of jellybean TTL [transistor-transistor logic] running around, not a lot of little off-the-shelf chips. Everything on there costs $4 to $9 apiece, and that's expensive for a chip. But we've got so few of them; instead of taking up board space with a lot of stuff that you just don't need and making it unreliable because you've got to have connectors and you've got all these problems with soldering. If you just carefully pick what chips you want to use and you've got somebody like Burrell who's genius enough to put the right ones together in the right way and make them do things they've never done before, then you can come out with *something* that's small and inexpensive and incre*dibly* powerful.

Smith: What gets me is that a lot of programmers will have this long laundry list of things they must have before they will sit down and allow fingers to touch the keyboard. I was really lucky because these guys are the best programmers I've ever seen anywhere, not just with Apple. They walk around between the Apple divisions, contributing this amazing graphic stuff to Lisa—and then help out on the Mac, too. Everybody had this common goal of making the Mac



Andy Hertzfeld.

screen, just Bill's amazing software and Burrell's amazing hardware, then in between that the other amazing software that we have. We tried to do that in every single way, with the disk and with the I/O. . . rather than slots.

When we first started off with Apple II, the variability—how you customize your machine—was with hardware; you plugged in a card. And because we didn't have any idea what these computers were going to be used for, that variability was very important. But now we have a much greater understanding of what people are using these products for. And the customization really is mostly software now. The way I customize my machine to do what I want is by sticking in a disk more than anything else.

Atkinson: We've already built in the hardware that most people want.

Jobs: Right. Most of the options on other computers are in Mac. So Andy and Burrell really came up with an I/O scheme that was serial. We don't have slots. . . slots cost a lot of money, they make the box much bigger, and you need a much bigger power supply because you never know who's going to plug in what. Do you realize that in an IBM PC the video board, just the black-and-white video plug-in card, has got way more chips than the entire Macintosh? Anyway, so the Mac's got most of the stuff built in. Rather than putting in serial ports that operate at 9600 or 92,000 bits per second, we paid more money and we put in this super chip. We used the Zilog SCC chip that Burrell picked out, and Larry Kenyon and Andy wrote the software to make this chip sing. And it goes up to, what, 230 kilobits per second?

Smith: It can go up to a megabit per second with external clock.

Jobs: And it does all the asynchronous and tons of synchronous protocols all inside the chip. So we've got superhigh-horsepowered serial ports.

Smith: The whole idea is that later on we'll be able to have logical slots instead of physical slots. We'll be able to have multiple devices per port; we'll use a port a lot like the way you have slots in Apple II. But one of the other advantages that Steve didn't

flexible and general-purpose because we didn't know what we might want to do five years from now. We knew the kind of direction we were going, so instead of building in a graphics controller that takes 25 chips and then trying to figure out some way to soup up the architecture so that it actually would work with it, we relied a lot on the processor assembly-language code in ROM [read-only memory]. And it turns out that we can make the whole system go faster by eliminating a lot of the bus traffic that normally slows the machine down.

Jobs: We learned a lot on Lisa.

Atkinson: We're still learning a lot!

Jobs: If you read the Apple's first brochure, the headline was "Simplicity is the Ultimate Sophistication." What we meant by that was that when you first attack a problem it seems really simple because you don't understand it. Then when you start to really understand it, you come up with these very complicated solutions because it's really hairy. Most people stop there. But a few people keep burning the midnight oil and finally understand the underlying principles of the problem and come up with an elegantly simple solution for it. But very few people go the distance to get there.

One of the things we really learned with Lisa and from looking at what Xerox had done at PARC [Palo Alto Research Center] was that we could construct elegant, simple systems based on just a bit map. . . no character generators. . . and save tons of chips if we had software fast enough to paint characters on the screen, given the processor. Apple was the first company to figure out how to do that with a microprocessor. . . and really still is the only company that's doing it with a microprocessor. That's what Bill figured out how to do with Quickdraw.

The real reason that we chose originally to use the 68000 was so we could pick up Quickdraw. Macintosh uses the exact same graphic structure and package, the exact same code, as Lisa does. So, by paying a little more for the microprocessor, not only were we able to give the customer an infinitely more powerful chip than, say, an 8-bit chip or one of Intel's baby micros, but we were able to pick up this amazing software, and that allowed us to throw tons of chips out of this thing. We didn't have to get special custom text or graphics chips. We just simplified the system down to where it's just a bit map on the

mention is that you don't have to change the memory map of the computer. Andy and Larry Kenyon worked on the system and the driver software and things like that. They said, well, gee whiz, on the Apple II you keep having the rug sort of changed on you; someone plugs in a new card or, worse yet, on other micros people are plugging in different software and different hardware, and it's hard to keep track.

Atkinson: You get into incompatible combinations; you just can't use this card with that card.

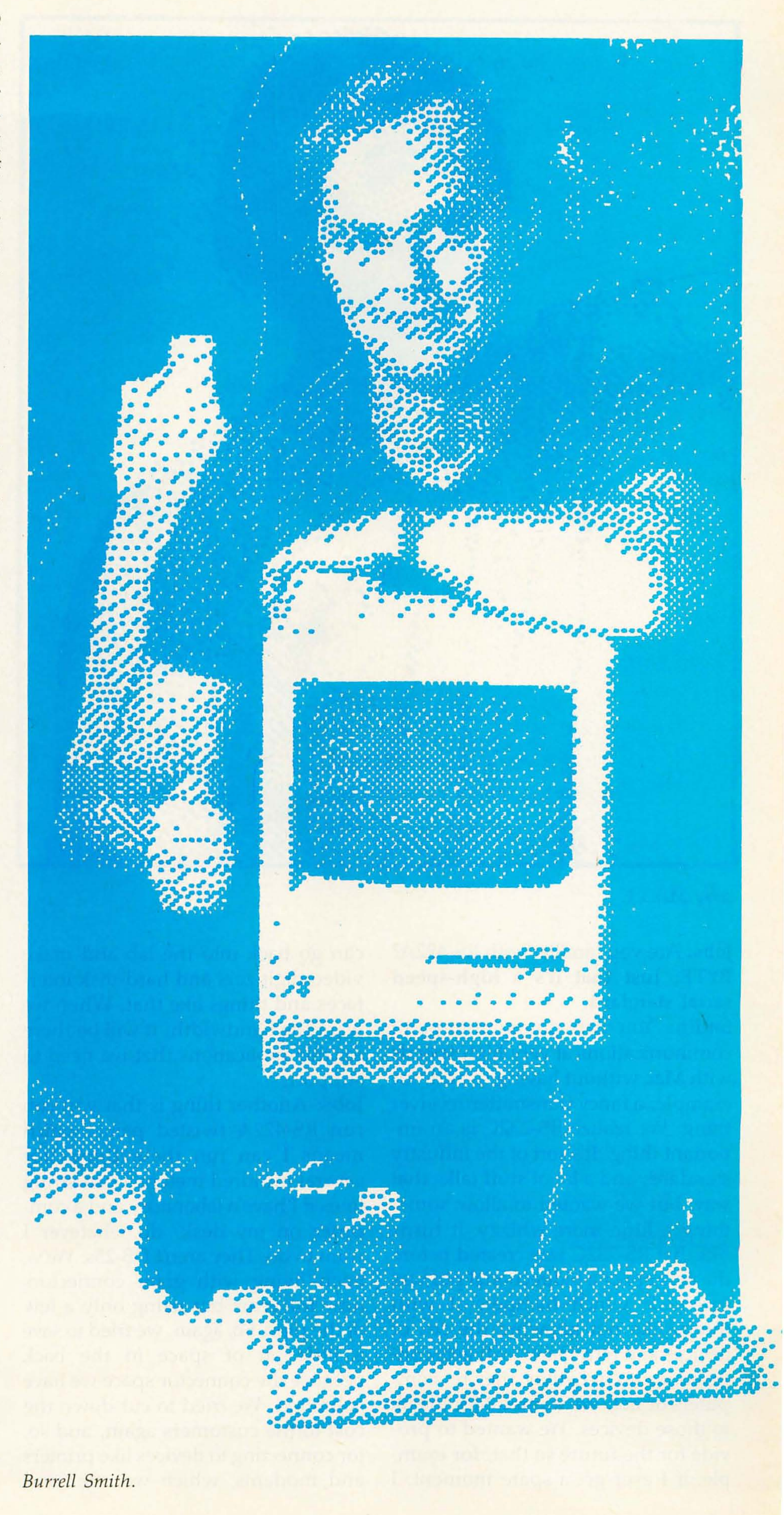
Jobs: The other thing about the hardware is that when Apple II was designed, a microcomputer system cost a lot of money to build. I mean, to get a microprocessor and RAM [random-access read/write memory] and ROM might have cost $50, $60. You obviously wanted to share that among the peripherals, which is what the Apple II did, what any slotted system generally does. Now you can buy a microprocessor and RAM and ROM in a single-chip micro for about $4. So giving each of the off-board peripherals its own little microprocessor system is adding $5 to the cost of the peripheral. And the cost for providing them with the bandwidth that's needed for most of the peripherals that are not on this board is very low. Add a $5 bill to the peripheral, put a single-chip micro in it, and then talk serially, rather than have every single user pay an extra few hundred dollars for the price of the slots that may never get used.

Atkinson: One way to look at the bandwidth thing is real simple: if there are 128K bytes, that's an eighth of a megabyte. There's 1 megabit in the machine, so the worst transfer you could think of, transferring the entire contents of the machine, takes one second. You transfer the entire contents of the Mac through that serial port in one second.

BYTE: What are the serial connectors?

Jobs: There are two connectors, DB9s. . .

Atkinson: They're tricky. They can run anything from 300 baud on up; you can use them as RS-232C or RS-422A.



Burrell Smith.



Jerry Manock.

Jobs: Are you familiar with RS-422A?

BYTE: Just that it's a high-speed serial standard.

Smith: You can do point-to-point communications at very high speeds with Mac without having to add, for example, a fancy transmitter/receiver thing. We realize RS-232C is an important thing. It's sort of the industry standard, and a lot of stuff talks that way, but we wanted to allow something a little more whizzy. It turns out that RS-232C was created before the concept of a bidirectional pin was invented, which hampers it with things like not knowing the sex of devices and terminals. . . . It gets confused as to whether they're computers or not. We wanted Mac to talk to those devices. We wanted to provide for the future so that, for example, if I ever get a spare moment, I can go back into the lab and make video digitizers and hard-disk interfaces and things like that. When we want the bandwidth, it will be there for the applications that we need to support.

Jobs: Another thing is that you can run RS-422A twisted pairs, which means I can run these things for several hundred meters. I can string lines if I have a laboratory and a computer on my desk, do whatever I want to do. They aren't DB-25s. We've been living with giant connectors now for years but using only a few of the pins. So, again, we tried to save a little bit of space in the back because the connector space we have is limited. We tried to cut down the cost to the customers again, and so, for connecting to devices like printers and modems, which we offer and which are the most prominent, we just supply the cables. We also will supply cables from one of these things to a variety of DB-25s. . . for the modem version, the printer version. . .

Atkinson: Lines 2 and 3 are switched on a modem versus a printer, so you just use a modem cable or a printer cable.

BYTE: From a very early time you knew that you wanted to take advantage of Lisa's software technology, and you also had the goal of making that possible at low cost. When did you have a consensus on exactly what this hardware would have to be to achieve that goal?

Smith: In 1981 we started looking at the Lisa. I came up with a proposal that said it ends up costing $14 more to use a 68000 with 64K bytes of memory than it does with 6809-based machines, if you count power supply. It turns out that it's actually easier to interface memory to a 68000 than to a 6809. So in January we started really looking at the 68000 and the work that Bill was doing.

In June of 1982 we finally decided on what we thought was enough video. It turns out that the original machine had 384 by 256 pixels. We chose that because we thought we had a shot at squeezing the machine down into 64K bytes, and we didn't want to throw away a quarter of the memory just for the screen.

Atkinson: The thing that drove us is the 80 columns. In a word processor, we really wanted the lines to break on the screen at the same place they break on the printer. There are two kinds of word processors. There are the ones where you just have a string of characters and you see them however they wrap on the screen. Screen wrap is a function of the screen, and how characters wrap on the printer is the printer's doing. Then there are word processors where what you see is what you get. You lay out a line and you know it's going to break at the same place on the printer as the screen, so you can do columns and tabs and a couple of columns of numbers. Then you have to have enough pixels to generate a full printer line across. We thought we could do it

The Wizards behind the Macintosh

Bill Atkinson *nearly had his Ph.D. in neurochemistry before he admitted to himself that his real love was computers. He "got a quick E.E." and started his own company. He was happily minding his own business when his friend Jeff Raskin asked him to come see what was happening at Apple, which was then six months old. Bill wasn't really interested, but airplane tickets showed up in the mail, so he took a look. What he saw was "several years reaching into the future" of anything he could do where he was. He stayed to write Apple's Pascal and later became Mr. User Interface for Lisa before he moved over to the Mac team.*

Andy Hertzfeld *says, "The Apple II changed my life." The computer people at Berkeley were a little narrow-minded about letting a grad student really get into the computer as Andy wanted to. So he spent nearly all the money he had in the world on an Apple II and had a computer he could control completely. He decided the Apple was more interesting than his classes and began writing programs for magazines. When Apple bought one of Andy's programs, Steve Jobs offered him a job, which he took when he finished school. He worked on silent-type printers and Apple III demos until a shake-up in his part of the company shook him loose. He looked around and decided to go with Mac.*

Larry Kenyon *arrived at Apple from Amdahl with a double degree in psychology and computer science. He was working on Apple II/Apple III products when the same shake-up that shook Andy loose freed him, too. Andy asked Larry to join the Mac crew because he was one of the few people who understood the arcane art of making the Apple II work with printer peripherals, and anybody who can do that has to be good. No one in the company really believed that Mac was a product when Larry joined the Mac team. It was just a research effort, and there was some risk involved—would you still have your job in a few months?*

Joanna Hoffman *is still on leave from her Ph.D. program in archaeology at the University of Chicago. She has a background in anthropology, physics, and linguistics. She came to Apple because of Mac. After using her computer skills in the field of archaeology for so long, she was tired of looking at the past and turned to the future. She was Mac's entire marketing department for more than a year. She wants to make Mac a tool that feels natural for international users by making it speak their languages.*

Burrell Carver Smith *encountered the Homebrew Computer Club in 1975, got hooked on microprocessors, and moved to the Bay Area. Just riding around in a borrowed truck one day, he saw Apple and decided to drop in. The only job Apple had available was in the service department, repairing Apple IIs. He took the job and fixed at least a thousand Apple II boards and got involved in other projects before Jeff Raskin and Bill Atkinson recruited him for Mac. He talked the Lisa engineers out of some chips and stuff and got a prototype running over Christmas 1979. He was the first full-time Mac person after Jeff Raskin.*

Chris Espinosa *says, "There was no life before Apple." At 13 years old he could be found cruising up and down the bus line in his home town, spending a few hours at each Byte Shop on the line until the owner threw him out. He discovered the way to keep from getting thrown out was to write demo programs for the machines, so he wrote for whatever was lying around—Altairs, IMSAIs, or this weird new machine called Apple I. His mom worried when he was offered a ride to the Homebrew Computer Club meeting with two scruffy characters named Jobs and Wozniak, but she gave in, and the rest is history. Chris spent a Christmas vacation debugging Apple's BASIC in exchange for a whole row of 4K-byte RAM chips, which he thought was a pretty good deal. He worked part-time during college writing BASIC programs and reference manuals and signed on full-time when he graduated. He likes being in on the design process—"If the machine is designed right in the first place, you don't have to write a lot about it."*

Jerrold C. Manock *was a freelance product-design consultant with a Stanford education who finally joined Apple when he saw that three-quarters of his billing was to Apple anyway. He worked on the Apple II, the Disk II, the III, and Lisa before designing Mac. In Macintosh, he says, "The outside matches the inside in elegant simplicity."*

Bruce Horn *grew up at Xerox PARC, much the same way Chris grew up at Apple, and later attended Stanford. Bruce started working at Xerox when he was 14 years old—he was one of the kids Xerox brought in to test Smalltalk. Turns out he was brighter than most and became a systems wizard who actually implemented Smalltalk on a variety of different processors. Bruce is all of 23 years old now, but he spent seven years at Xerox PARC and brought Apple that perspective.*

George Crowe *and* **David Egner** *designed the analog board in the Macintosh.*

Steve Capps *assisted Andy Hertzfeld with the systems software.*

with 384, and we tried it with real live documents—and we couldn't do it. You could do it with 512, but you couldn't do it with 384.
Smith: The diagonal lines look better, too; the jaggies are removed somewhat, and things like that. So, with that, we said, OK, what's that going to mean? And we ended up with 128K and...
Atkinson: 22K bytes on the screen, and in a 64K-byte machine you couldn't have afforded it. That drove us to 16 RAM chips instead of 8.
Hertzfeld: By then, we knew we were going with 128K bytes anyway, to run the applications.
Jobs: I just thought I'd show this to you. This is the IBM video board; it's only video, nothing else. It's 69 integrated circuits, more chips than an entire Macintosh, and it basically does nothing. And it doesn't even do that very well.

Espinosa: Forty percent more chips than the Mac.

Jobs: So that sort of gives you a feeling. And again, that just has the video on it. Macintosh, in addition to having video that's far higher in resolution and far faster, has a 32-bit microprocessor, 128K bytes of RAM, 64K bytes of ROM, two serial ports, the mouse, the serial, keyboard, and mouse interface, the incredible sound, the clock calendar, the disk controller. . .

Smith: We rolled the whole disk controller into one chip.

Hertzfeld: And it has Lisa's graphics and user-interface software built into every board.

Jobs: Andy was sort of the software technical leader behind the project, from its inception. As Andy puts it, software sometimes stands on its head to get rid of a chip in the hardware. And so, with a system as powerful as this, we wanted to take advantage of all the features, for instance, in the serial chip and the disk and stuff. We really wanted to be able to have the serial ports reading while the disk is spinning, while the mouse is moving, while it's making sound. You know, all with that single board.

BYTE: What were the roots of that operating system?

Kenyon: When we started, of course, we were looking at the work Lisa was doing, and the Lisa group was rolling its own operating system, and it just didn't seem appropriate. We took the graphics software, which was perfect for our machine.

Capps: The Lisa's operating system took a lot of the user interface. For the window manager, even the memory manager, we started with what Lisa had.

Hertzfeld: It turns out that Quickdraw is built on top of what Lisa would call the intrasegment memory manager. You relocate little objects. We took that because Quickdraw required that support, and we sort of turned it into our system-wide memory manager. Even the Lisa group uses it only for the intra-application memory manager. Someone mentioned a neat way to do a file system, and we thought about it and said, "Gee, that's a good way of doing it," and so we did. A lot of it was experience on the Apple II, knowing what was sort of bad there—what we wanted to do great here. That at least was the conception of the asynchronous I/O. I knew from the Apple II that when you make a disk request it waits there for a whole second, a million microseconds, just waiting for the disk to come up to speed. We should be able to do other useful work while that's happening. On the Apple II if you want to make a beep, the whole processor, the entirety of the machine, is devoted to making a beep. And when you've got all the horsepower of the 68000 there, you don't want to waste it all on making sounds.

Atkinson: We still make a beep with the processor.

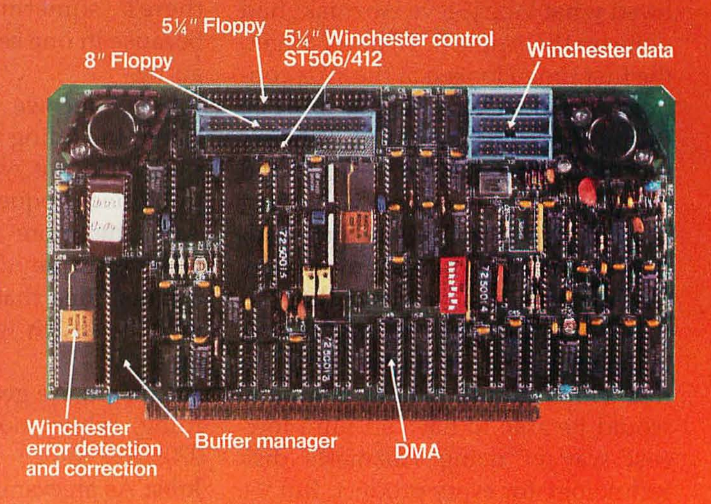
Hertzfeld: But we time-slice the processor such that you can be doing other things. It happens on the interrupt level instead of being dedicated. Macintosh uses the processor for everything, just like the Apple II does. In terms of the disk, we have

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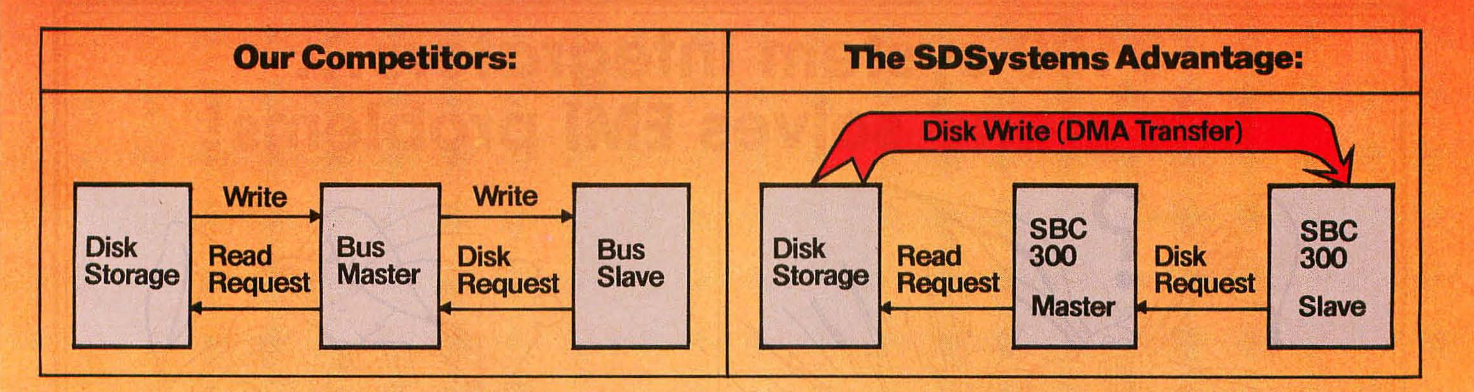
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the same disk-controller architecture as the Apple II, but we are just a little more sophisticated in how we use interrupts. We give the time back to the applications while the I/O is going on.

BYTE: Can you say more about the custom disk controller?

Smith: Sure. A long time ago we sort of figured that everybody who was doing designs at Apple with disks loved what Woz [Steve Wozniak] had done on the Apple II. I'll never forget, the first time I looked at the Woz controller I said, "OK. Well, this must be the interface disk controller. Where's the disk controller?" I never found the disk controller. And we've just been in love with the way that that's done. It's used to modify group code. One of the things we knew, though, was that disks would be going faster in the future. So we initially designed this chip so the whole company would be able to have an ultra-low-cost way of using Wozniak's disk technology for every product. But we knew that we weren't just going to be going at 4 microseconds per bit, that twice that would become an industry standard . . . at least an Apple internal standard. So we built in a mode, a high-speed mode, so that it can go twice as fast.

Atkinson: While you're getting input from the serial port at 19,200 bps, you can be writing to the disk and not missing a beat. It's not the buffer that's doing that. It's Larry Kenyon. Every 4 nibbles, you look to see if there's something on the port, because in one sector's time, 24 bytes go by.

Jobs: After we reexamined everything, including the disk format, we said, "Do we want to go to MFM [modified frequency modulation]?" And the more we reexamined it, what became clear was that the original idea that we had for a disk in 1978, which we are still using, is great.

Atkinson: We get 400K bytes on this thing, while most people get only 270.

Jobs: As an example, our scheme has twice the margin of MFM. In other words, when you're shipping a million or two million computers a year, which we intend to do, when people are buying media from 10 different sources and they expect to take disks out that were recorded in Alaska in really cold weather and stick them into machines in Florida in a heat wave and have them work, that margin is really important. If you want to equate that to reliability, we are significantly more reliable than any other disk system on the market, while having higher capacity. So that was the key decision, to stick with the same encoding format and the same scheme that we've used since 1978. So, while everyone else is running at roughly the same rates as Apple II, the IBM PC, and everything else, we doubled it on Macintosh. We set a new internal standard with the 3½-inch disk and this new single-chip controller. And every new 32-bit product at Apple will use that new standard. The media, the sector format on that media, the disk controller, and the routines and everything to drive them is a new Apple 32-bit standard that you'll see com-

ing out in every future product that we do in that family.
Smith: There were some voices within the company that said, "Oh, you guys ought to go with standard formats and things like that." We looked at doing that and it turns out that it takes more chips to interface to a standard floppy-disk controller, and we have...
Jobs: Well, I can go get the IBM floppy board. It looks to have about 45 to 50 chips on it...
Espinosa: I'll come and help you carry it.
Jobs: ...including an LSI [large-scale integration] disk controller—far less performance, far less capacity, far higher cost.
Atkinson: And less reliability.
Jobs: Oh, far less reliability. Larry's software senses the disk speed, and Burrell's hardware can adjust to one of four hundred speeds. So if it's written on something that's a little out of whack, we can just adjust right down to the necessary speed and read it. Everything on the Macintosh board—the serial timing, the disk timings, the microprocessor timings, the video timings, the sound timings—comes from one crystal oscillator and is synchronized from one source. And, again, it's better, of course, technically to do it that way. Everything works much better, but it also saves parts, and we can offer this thing cheaper to customers. And most of this stuff customers will never ever realize or care about anyway. I mean, who cares how many crystal oscillators you have? But you *do* care about how big your computer is. You do care about how much it costs, and you do care about how well it works.
Atkinson: If you ever drop your computer you find out quickly how many crystal oscillators you have.
BYTE: So with the variable speed in the disk drives, I guess there's no problem having two drives that are 3 percent different in speed.
Jobs: We read it and adjust it so that the speed is accurate relative to that crystal. That crystal on the board is superaccurate. We can adjust the disk drive relative to that superaccuracy.
Atkinson: You force all the disks to go at exactly the same speed by having the software constantly monitoring the speed and saying, "Ah, it's running a little slow; jack it up a little bit," so that each disk doesn't have to be adjusted at all. You switch disk drives, and the new one will run at exactly the same speed because you force them all to.
Smith: It turns out that the speed variations occur partly because you plug in a new cassette that loads the motor down in a different way and also because of temperature variations that cause very long-term drifts in the disk speed. Using a little bit of the processor to fix that doesn't cost us any performance at all on the system.
BYTE: What about the display electronics?
Atkinson: Where is the display controller?
Hertzfeld: It's hidden.
Jobs: If you bite into that IBM display board, it'll totally flicker if you do it at the wrong time. You've seen that, right? Woz just came up with this really brilliant way to do the Apple II. He realized that memory was about twice as fast as the microprocessor needed it and twice as fast as the video needed it. So he put the microprocessor over here and he put in essence the video over here, and he put some multiplexers in the middle. He shared the exact same memory between the two in a way such that this one thought it had all the memory all the time and this one thought it had all the memory all the time, yet they shared the same memory! All this thing had to do was write into certain memory locations and, magically, it would appear on the screen. The microprocessor never even had to think about the screen. All it did was look at memory locations.
Atkinson: And there was no way to glitch the video because accesses were mutually exclusive.
Jobs: Right. And so it turns out that, try as we might, we have never been able to find a better way to do it.
Atkinson: At the same time that the processors have gotten faster, memory's gotten faster; the memory is still twice as fast as the processor.
Jobs: And so, again, it gives you greater performance, because you don't have to write only at special times and slow yourself down. It cuts the chip count way down because you don't need two banks of RAMs, so the customer's not paying for these extra chips, and it just makes a more elegant product.
BYTE: How far does the similarity extend between the Apple II video and the Mac's video?
Smith: We have a three-part memory architecture on Mac. We have a DMA window for sound, video, and CPU...shared by three devices. Also, what we do that is a little more sophisticated than Apple II is return memory cycles to the processor during horizontal and vertical retrace. And with the analog design we're able to lengthen the horizontal retrace interval, which gives us more performance for graphics by making more time available to the processor from memory and giving the analog electronics more time to retrace the beam. On the Apple II, Woz sort of designed this logic board and the power supply was kind of added. On Mac, we really designed the entire system as a complete system from the ground up, so we used different constraints. I would say there's not much similarity. The great thing about Mac as a product is that it really wasn't designed as just this piece over there and this piece over there and this other piece...All of it was designed in parallel, everybody knowing what everyone else's job was.
BYTE: How did you decide on the appearance of the machine?
Manock: Our goal in the beginning was portability. We actually had this cardboard model that looked amazingly like the Osborne. And that was way before the Osborne came out. As I said, portability was primary here, and this version had an attached keyboard that had a sort of rubber boot around it that would fold up and give you protection over the screen. Steve really changed the emphasis of the product one day when he said that we didn't want portability to be the primary aspect of this, but we did want it to take minimal desk space. With that goal in mind,

we realized that the keyboard didn't have to be exactly the width of the computer.

Jobs: To use the earlier design you had to have some sort of arrangement to tilt it up. And what we noticed was, well, fine, what if you just lift the back up here like this? Then, because you have all this space underneath, you could put the floppy disk underneath. So you make a unit that's more vertical, has a smaller footprint.

Atkinson: It has to be up enough so your eyes can see it anyway; you need the height.

Manock: Steve thought, too, I think—in a gut reaction sort of way—that everybody was going low profile and wide, and we never have wanted to be a "me, too." I think our vertical format is correct when you think of human factors.

Hoffman: Jerry, you might want to turn the back around. We made it truly international. I think it's one of the few products aside from Lisa that is completely usable anywhere you care to take it.

Manock: Did you see the icons on the back?

Hoffman: We started out with the case and went from the outside in, trying to make it more and more international the more we thought about it. And Jerry was just great as soon as he realized that we really did want to bring it to the whole world. He had marvelous ideas on how to eliminate every word of text, take everything off the package so that we don't have to be an American product anywhere that we go.

Jobs: In Mac, there's no English on the outside of the case. Everything's iconic. And there is absolutely no English in the ROM. It is universal in nature. When the thing comes on it puts a few icons on the screen. If something goes wrong, it can't boot or something, it puts a frowning Mac on. If it's booting it puts a happy Mac on. It loads all the languages, all the country-specific stuff, off the disk. So, because the keyboard is detachable and mapped anyway, to localize Mac all you do is change the keyboard, manuals, and the disks. Nothing in the box has to change.

And another real breakthrough is this thing called Resources that Bruce Horn invented.

Hertzfeld: The data is factored out from the code. You know, most programs are a mixture of control logic and just raw code.

Atkinson: The virtual-memory architecture on the data parts of the program allows us to factor it out so that, without rewriting a program at all, without recompiling or relinking the program, I can take a copy of Mac Paint and in 15 minutes make a German version.

Hertzfeld: Because all the text is kept in a well-known, well-defined place.

Horn: Until December, people didn't really know what the resource manager was, because they really hadn't had any contact with it, besides me. I knew what I wanted from it because I had to do Finder and all that other stuff. Andy just looked at it over time and figured out what you could do with it. And I was trying to say, well, this can do this and this. . . It was really Andy having the biggest view of the system saying that this could really be a great thing for a lot of stuff.

Hertzfeld: Another thing to ask Bruce about is the Finder, which is our most important application, the first thing that comes up on the machine. That's the program with all the little icons, the desktop manager, I guess we're calling it. That's Bruce's conception and communication.

'In Mac, there's no English on the outside of the case. Everything's iconic.'

Hoffman: There are numerous subtleties with this. Picture a dialogue box, for example. A dialogue box, when you put English text in German, starts overflowing its limits and starts looking very different. You have a button that says, "Put this away." In German, that takes a paragraph and overflows the box. . . . But Resources lets us change not only the text but also the physical look of those dialogue boxes, or anything, through *something* called Resource Editors.

Jobs: Otherwise, you'd have to get into the source listing. You'd have to change not only the languages, as Joanna said, but also the geometries of the dialogue boxes and make them bigger. It would take you awhile; it's not something that's impossible, but it's something that never gets done. And it's certainly something that you have to be the originator of the program to do. What we've done by pulling all the language-specific stuff out, through this beautiful mechanism called Resources, is write these other programs called Resource Editors. By running a Resource Editor, you could, if you knew German, simply run a program on the program, get in there—literally on the screen—and just stretch the boxes bigger. You could select a text and retype it in German and move things around if you wanted. You can examine every icon, every dialogue box, every alert box, every pull-down menu, everything, without being a programmer,

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without getting the source code, and very quickly, too, using the user interface of the Macintosh.

Atkinson: Anything that XYZ software company put together, even though the company didn't think about Taiwan, will run in Taiwan.

Jobs: But do we want it to run in Taiwan?

BYTE: Are you going to market it aggressively in Japan?

Jobs: Yes.

Hertzfeld: My favorite thing about Resources, being selfish, is that the same facilities that allow us to translate English into 7, 10, 20, a million different languages are the same facilities we use to translate technish to English in the first place.

Hoffman: The other component of this is that it allows us to not just introduce products that feel to the native user like a native machine, natural to them, but also that we can start coming very close to making simultaneous product introductions. The software that is developed in the U.S. can fly over there for them, for the fragmented markets in Europe, for example. Europe does not allow for the same kind of development of software houses as the U.S. because the markets are all so fragmented you can't amortize development of the software over as large a user base. But given that the Europeans now have the capability of using a localized, *globalized* software, if you will, their market grows because each individual software developer in France now can view the whole world as a market. We feel that it will give an impetus to the development of software developers, third parties, in Europe, and in more fragmented markets as well.

Smith: An international power supply, too, so the exact same unit basically can be used anywhere in the world.

Egner: It doesn't care whether it's 50-Hz input.

Manock: Just one additional thing on these: the icons on the back are from the International Electrotechnical Commission (IEC). We didn't invent all these ourselves. . .wherever possible we used symbols that already existed—for example, AC line power—that are world standards. Where we didn't have symbols that existed, we used the IEC's closest symbol as best we could and then added what we thought made sense. For example, we needed a symbol for a modem, so we started with IEC's telephone symbol. We tested them to make sure there was good recognition. We'll submit these new icons to the IEC to have it suggest that they be the standards added to its encyclopedia of symbols.

BYTE: What is this machine going to make possible that other comparably priced machines have not made possible? How will it change the personal computing scene?

Jobs: Right now, as you know, when you use a word processor, it will do two or three things. The first thing Macintosh will do is make the existing types of applications an order of magnitude easier and more approachable for people. Therefore the available market for this machine is going to be giant compared to the available market for the people who are willing to invest 40 to 100 hours learning to use their computers. That's the first thing.

The second thing is that there are going to be new types of applications available that could not be available on the current generation of personal computers—it is technically impossible to do. The perfect example is Paint. Paint is impossible to do on an Apple II or an IBM PC or any of the other first-generation products. You can do a mockery of it, but you can't really do it. And there are going to be lots of applications like that. You've seen Lisa Project. That, of course, will be running on Mac. And we don't even know the kinds of applications that are going to come out in six months to a year. As an example, we'll be able to laser-print output from this thing by next June, and that is pretty exciting to us. So, if we sell these on a university campus, you'll be able to take your disk into the library and get output off a laser printer, which will be approaching typeset quality. That's the kind of stuff we're doing; you just can't do that on a current-generation personal computer.

And then the third thing is what Burrell and Larry and Andy and the other software people have done. When we shipped the Apple II, we fundamentally shipped about 2K bytes of ROM with system code. The IBM system's got 8K bytes, but it's really kind of loose as a goose; it's about 4K bytes by our standards of code. Mac has 64K bytes of the tightest, most elegant code that this company's ever written. Most of the computers now are basically shipping a file system and a few drives, but what's really interesting is that on top of that, we've layered on memory management and on top of this is Quickdraw.

Jobs: Mac's a completely open machine—we've got a book called *Inside Macintosh* that tells all the secrets of it. But we're going to try to get a little uniformity through the carrot rather than the stick. And the carrot is that there's a finite amount of RAM in this machine, and we've done all these things for you in ROM. Now, you can do them yourself, there's nothing that says you can't do them yourself, but if you do, you've got to write them, which is going to take time and means you're going to be slower to get to market; you've got to chew up precious RAM space, and the chances are pretty good that we did a better job than you'll do. So we're going to try through the carrot to get a little bit of uniformity in the user interface in some of the ways the things are done.

Hertzfeld: See, we're really a 192K-byte machine, and if the programmers want to throw away 64K, then they're doing a dumb thing.

Jobs: We're a 192K-byte machine that deep-freezes 64K.

Hertzfeld: Highly tuned, tested, debugged, highly compact, very fast, very high-quality consistent code.

BYTE: What are all the factors in this that make it go so fast?

Hertzfeld: Sweat.

Jobs: Burrell, Andy, Larry, Bill—how long did you work on Quickdraw?

Atkinson: Four years.

Hertzfeld: All of us care a lot about performance. Surprisingly, that's unusual. A lot of people don't care if their system's. . .



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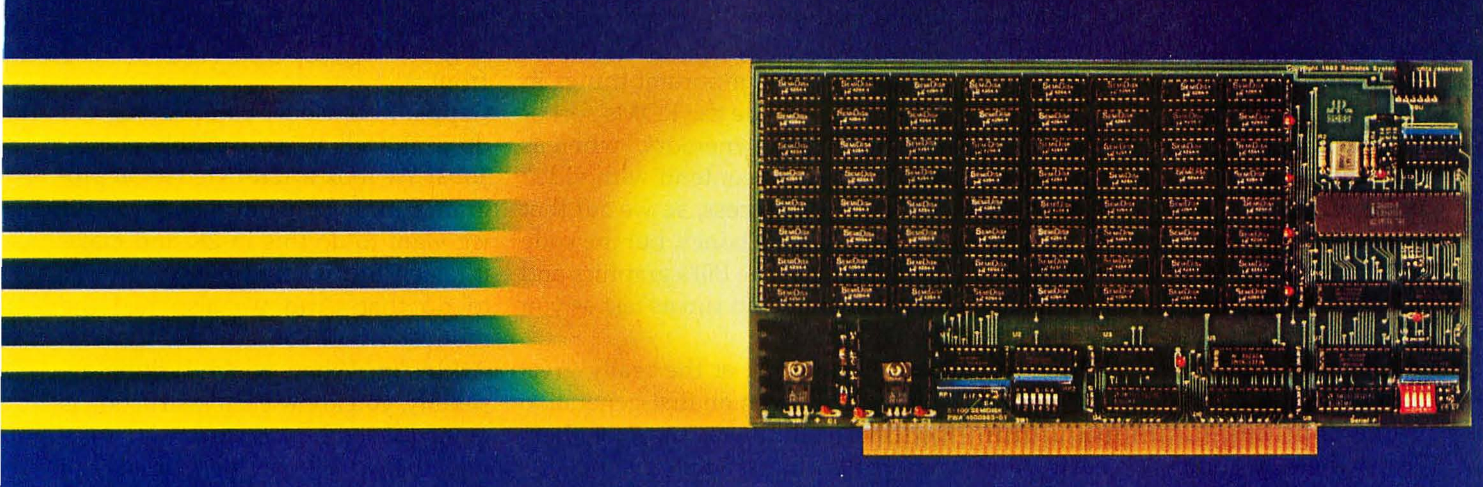
Atkinson: Like Quickdraw. I won't even count the first runs in Pascal, but the first runs in assembly language were running 160K bytes, before I added a lot of the new features. It's now down to 24K bytes with lots more stuff in it. Character-drawing speed is one you look at for drawing an arbitrary size character, an arbitrary starting pixel clipped to an arbitrary area. We were running, when it was being developed on Lisa, about 1000 characters per second the first time. Well, I got that up to 4000. Mac is running about 7000. That's seven times 9600 baud. This is typical of all of our software packages here. You go through, get the best algorithms first, get the stuff right. Then crunch it down, make a first pass in Pascal, get the algorithms right, find the cleanest algorithms, find all the corners, and make sure they're tested. Then I translate it into loose assembly language to get down into assembly language and get it working. Then I'll go through and get all the bugs out again, and I'll go through and do fine register allocation to figure out what's the most important thing. This little baby, the 68000, has sixteen 32-bit registers sitting there, and the way you get performance out of that is to keep them full. Keep the registers full of important stuff all the time. That's the way you make this processor sing. So you go down and you do register allocation, and then you don't stop. Then you feed it back, you get your people to use it.

'Optimization without measuring is wasted time. Find out where the application's really spending time and go whump on that code.'

Quickdraw was designed by "pull" from applications rather than "push" from the design team. You provide a facility, watch the applications group try to use it, understand where they misunderstood something—maybe you've got a bad model, you want to make it simpler and cleaner—or where they don't have enough performance. And then you go back and you measure, measure, measure, measure. Optimization without measuring is wasted time. Find out where the application's really spending time and go whump on that code. And any other cases they're very seldom using, squeeze them down in size, and stretch the other ones. There's always a trade-off between size and speed. Stretch out the common cases, let them be bigger and much faster, and then keep the generality by squeezing down the infrequent cases. So play your odds. People draw characters in OR mode a whole lot, and OR mode is about twice as fast as the other modes, so 95 percent of all characters are drawn in OR mode. Statistical measuring of the use of the thing allows you to get much more performance on your average throughput than you can if you don't go back and measure.

I think we all believe that system software should be done in assembly language at this stage of the game because high-level languages can't

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give you the performance and the code density that you can get out of assembly language.

BYTE: So far, it has seemed that with all the systems that have mice, all those that are on the market, you pay a great price in terms of performance to get ease of use.

Atkinson: You make a responsive system; it isn't just draw some characters out there. It's also, remember where you put them because if the guy touches on them you want to light them up. There's a lot more guts in that application.

Jobs: It's not just systems that have mice. What's happening is there are a whole bunch of things that go with the mouse. It's not just hanging a mouse on a first-generation personal computer and using the same old, fixed-pitch text and things like that, just replacing four cursor keys. What we've done here is take a quantum leap, where, in addition to having the mouse be the major pointing device, we've gone to full proportionally spaced fonts, totally software-painted on the screen, any size, any shape. . . totally new architecture for displaying things to the user.

Atkinson: But the responsiveness is where the code goes.

Jobs: The responsiveness and the fact that there isn't a mouse-based system out yet that uses a 68000. We're obviously using the power of the 68000 in addition to this code.

Smith: There are some tricks we played in the hardware, too. For example, we knew that the ROMs would have real important things in them. So we made the ROMs sort of read-only cache memory, whereas the RAM has to contend with video and sound for access, so we cut that down to the bare bones, but the code that's in ROM, like Bill's graphics and the other stuff, can run as fast as you can run a 68000.

Jobs: If you look at the really great applications, even on first-generation personal computers, most of them are written in assembly language—Visicalc, 1-2-3—it's like if you're going to sell a million of something, it pays to handcraft it in assembly. If you're going to sell 10 of something, it probably doesn't. If we'd written this in Pascal, we would have been able to fit a fourth as much code in the ROM or would have to have four times the ROM, and you wouldn't have had the performance. Because we're going to sell 10 million of these things in the long run, it pays to superhandcraft it; we only have to do it once. Every time these ROMs are burned, it doesn't cost us any more engineering. . .it's all been done up front.

Capps: Because we cared enough to do it as well as we possibly could.

Jobs: We took a 12K-byte Pascal program running on a Lisa and we said we want to do this in 2K and make it faster. But we had that extra year to do that. And we also had the motivation, of course.

Atkinson: When you're writing assembly, you know each instruction is going to take 2 microseconds, it's going to take 4 bytes of memory. In Pascal, you're removed from that, so you don't concentrate on performance as much. When I'm doing I/O stuff in assembly language I look at

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the theoretical maximum speed you can run at. Why not do it as fast as you can possibly do it? Especially when you're doing disk I/O stuff. How fast can you get into an interrupt and out?

BYTE: Andy, let's talk about the early days, after it had become Macintosh.

Hertzfeld: I don't know, there's something that makes a job a little more fun to work on when the odds are against you. And that's sort of how it was in the early days. I was maybe the fifth or sixth person to come work on it. Steve took me over to this little building separate from everywhere else, where there were these incredibly great people working on this little wire-wrap PC board. All it could do when you turned it on was write "hello" on the screen about 80 times. And everyone was incredibly excited to see it write "hello" on the screen because it meant that the central processing unit was there and all that potential was there to be mined. I spent my time mining that potential.

The very first time we got an early version of Quickdraw running, and we got the mouse going—that's just an incredible thrill. Or getting back the first PC board—we all went out for pizza on Friday night. We got the boards in about four o'clock Friday afternoon, and Steve said, "Well, if you get these done before midnight, we'll take you for pizza," and we stayed there. . . not because we wanted the pizza, but because we wanted to see that board working. And I think that none of our Mac PC boards have ever had to have a wire run to fix something, which is pretty amazing. That's the attention to detail that you just can't get people to do for money. We do it for love. . .this is the most important thing in our lives . . .to make that great computer.

It's fun for me because I like operating on a systems program where I can operate in an environment where there's not that much support. In the early days when I first started here, the first thing I did was come in and write all kinds of crazy demos, stretching things around on the screen and making balls bounce, and one reason to do it was that I didn't want to write the system code until I was good at writing 68000 programs. So I just wanted to learn by having fun, and the other reason is that it gets people excited about it. Just this raw hardware sitting there doesn't do too much, but once you start making this fun thing happen and that fun thing happen, the excitement starts getting generated. You get to attract other good people, and one by one we picked up on more and more people. We were very, very selective; it was very hard to find people to work on Mac software, because on one hand we had the very high goals of doing this research, Xerox PARC-like stuff with uncommon, high technical standards. On the other hand, we had a very inexpensive, limited-memory machine. So all the Xerox PARC-type guys who came and interviewed said, "Oh, you don't have 2 megabytes? Forget it, I don't want to work on this thing." They're all used to their Dorados. But gradually we found great people like Larry and Bruce who were turned on by the dream, and they came and joined our band, and I guess we reached critical mass.

Atkinson: Most of the early people were recruited from Apple. . . and we have a pirate's flag that we sometimes put on the roof. The idea is we're pirates and we go around and try to steal the best we can from anywhere we can get it, and mostly that's been from Lisa. A lot of it's been from Lisa, but it's true in initially putting together the team, too; we try to get the best people we can from anywhere in the company.

Hertzfeld: One of the slogans Steve came up with when we had a retreat in January was "Let's be pirates," the idea being that we were mavericks out to blow people's minds and overturn standards, create new standards, not do things like everyone else.

Atkinson: There was always the thrill that this was going to be the one project that was probably the most amazing thing you were going to be doing in your life.

Hertzfeld: And the other slogan was "The journey is the reward." ■

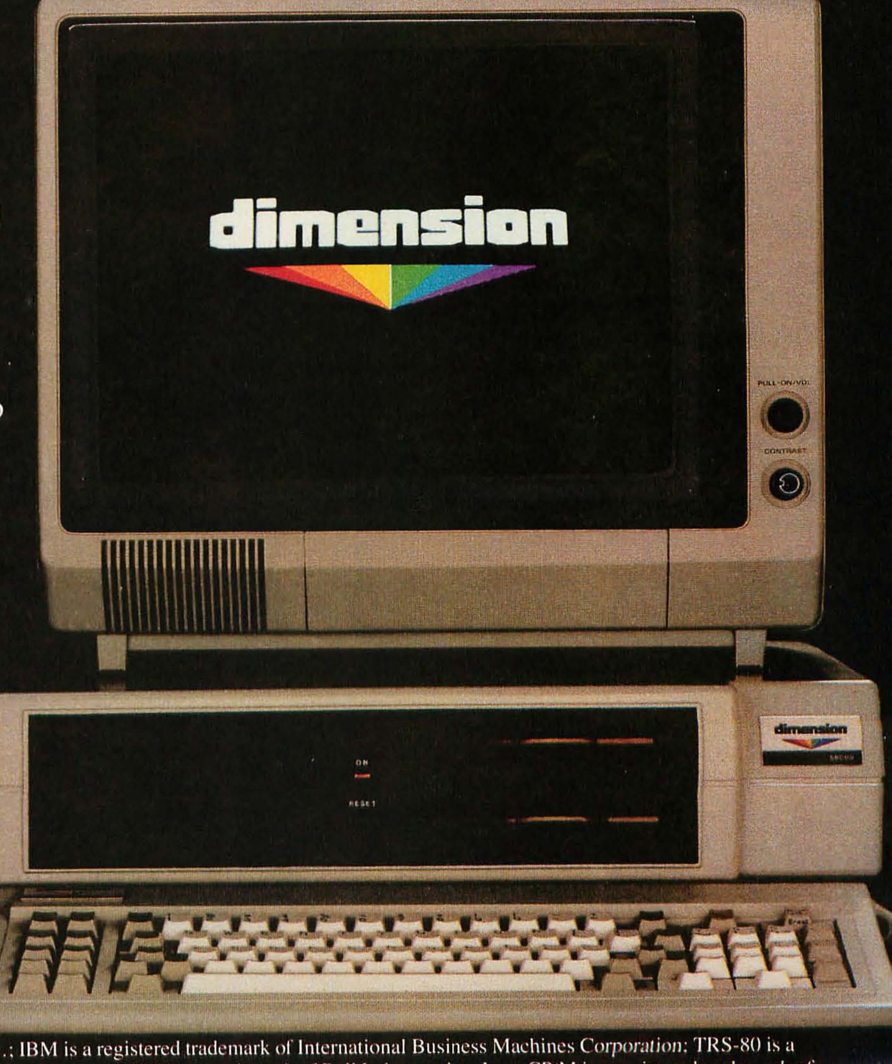
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The Lisa 2.

Apple Announces the Lisa 2

by Gregg Williams

When several of us at BYTE saw the Macintosh, we were seriously concerned about the fate of the Lisa in the face of the Macintosh, a machine that is one-third its price and clearly superior in some areas. Apple has answered these concerns by announcing two versions of the Lisa 2, along with the Macintosh, at its annual stockholders' meeting on January 24.

New Features

The Lisa 2 will use the same modified Sony 3½-inch floppy-disk drives as the Macintosh. It will be sold with a new, faster operating system, one 3½-inch floppy disk, and 512K bytes of memory (the single drive takes the place of the two 5¼-inch drives in the Lisa 1). The Lisa 2 includes a mouse, detached keyboard, built-in 12-inch video display, and can be expanded to 1 megabyte (the memory capacity of the Lisa 1); it will cost "under $4000," according to Apple (the exact price had not been decided when this was written). The Lisa 2/10 will add an internal 10-megabyte Winchester hard disk and will sell for "under $5500." All the Lisa application programs will be available separately for $200 to $400 each. Apple planned to have the Lisa 2 available by January 24.

Software

Aside from the availability of a larger hard disk, the most welcome feature of the Lisa 2 family is that it will be able to run all Macintosh software as supplied on 3½-inch disks. When the Lisa 2 boots a Macintosh program, the system will look and behave like a Macintosh, except that it will automatically take advantage of all the extra memory in the Lisa 2. Since literally hundreds of companies are developing Macintosh software, the Lisa 2's ability to run it greatly increases its software base and, therefore, its usefulness.

Both the Lisa 2 and the 2/10 come without an operating system. Lisa 2 owners will need to buy the Macintosh operating system (unpriced at the time this was written); Lisa 2/10 owners can buy that operating system or the multitasking Lisa operating system (for about $300). With the Lisa operating system only, you will be able to have multiple windows, each of which can contain a separate application.

Apple is planning two new releases of Lisa software as well. The first release, available in late January, has optimized various parts of the operating system to make Lisa programs run faster and use the 10-megabyte hard disk. This software release will be free for anyone who bought the Lisa before September 12, 1983 (when the price was reduced and the software was unbundled), and available at a nominal fee for buyers of unbundled Lisa software.

The second release of Lisa software will come sometime during the second quarter of 1984. This software will increase the integration among

Lisa products (for the first time, you will be able to move graphics from Lisa Draw to a text document in Lisa Write, data from Lisa Calc to Lisa List, and data from Lisa Terminal to Lisa Calc, for example). It will also include enhancements in many of the Lisa application programs. For example, Lisa Write will include a spelling checker and the ability to process form letters, Lisa Graph will allow data to be graphed in new ways, all programs will support a $5000 laser printer and a 70-megabyte hard disk to be introduced by Apple, and Lisa Draw and Lisa Graph will support color printing. The second release of Lisa software will be available to owners of previous versions for a nominal fee.

Upgrading

Lisa 1 owners have two upgrading paths. Apple will let them upgrade to a Lisa 2 for free or to a Lisa 2/10 for $2500 (both upgrades involve replacing parts in the Lisa 1, not swapping the Lisa 1 for a new Lisa 2). In both cases, Lisa 1 owners will keep their 5-megabyte Profiles, thus allowing them to transfer all their information to the new system (by copying all such data from 5¼-inch floppy disks to the Profile before converting to the Lisa 2).

Conclusions

With the announcement of the Lisa 2 and 2/10, Apple has made the Lisa computer both more competitive and part of an innovative, powerful, but still affordable family of computers. The reduced price and Macintosh software compatibility of the Lisa 2 make it far more attractive to potential buyers than the Lisa 1 was. The features added to the Lisa application programs make them even more useful than they currently are. Finally, Apple's upgrading policy is commendable because it does not leave behind the Lisa 1 owners who supported the machine in its early days. ■

Gregg Williams is a senior editor at BYTE. He can be reached at POB 372, Hancock, NH 03449.

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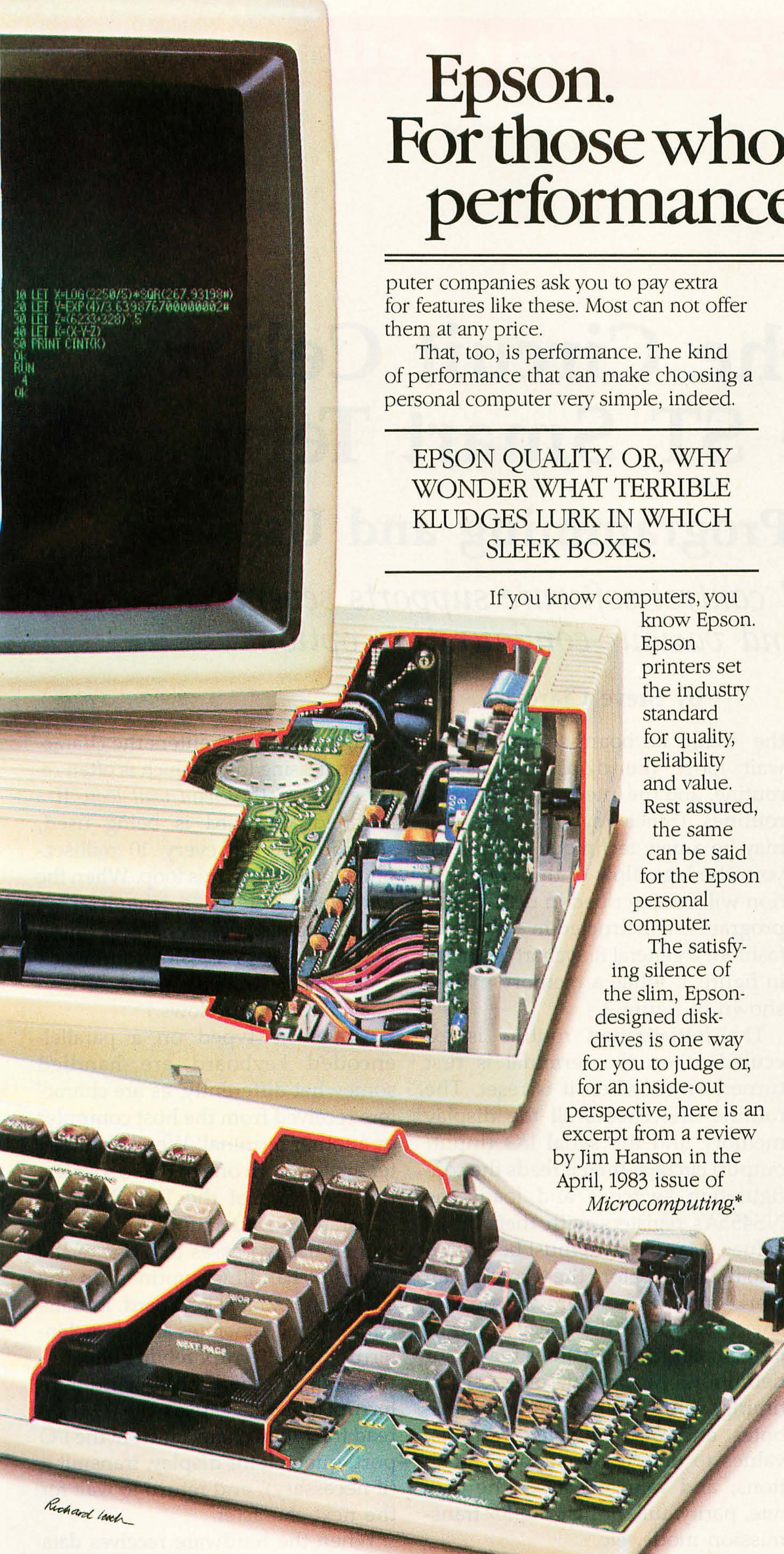
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Build the Circuit Cellar Term-Mite ST Smart Terminal

Part 2: Programming and Use

The supplied standard control software supports several character attributes and various configuration options

by Steve Ciarcia

Last month, in Part 1, I introduced you to the Term-Mite ST intelligent video-display terminal, shown in photo 1. It is designed around the new National Semiconductor NS455 Terminal-Management Processor (TMP). This self-contained terminal-controller chip permits the essential features (see table 1) to be provided by only 21 integrated circuits.

This month I'd like to pick up the story beginning with a discussion of the firmware, that is, the program logic inscribed in ROM (read-only memory) inside the NS455A that runs on the internal microprocessor to control all the terminal's functions. We'll look at the functions of the firmware, the configuration-switch settings, the Escape sequences and control functions, and, finally, demonstrate putting a few characters on the screen.

Factory-Supplied Control Program

The control program has four main sections: the initialization code, the main keyboard-scanning and wait loop, the display-processing routine, and the interrupt-processing routines. (Since keyboard scanning may be a new technique to some of you, the logic flow of this code section will be described in detail.) The program is constructed in a modular fashion; a general flowchart is shown in figure 1, while a memory map is shown in figure 2.

The initialization routine is executed when the terminal is first turned on or when it is reset. The routine first checks all the display memory and the serial I/O (input/output) circuits; then it reads the configuration switches and loads the NS455A's registers with their initial values. Many values must be loaded into registers before the terminal can work: among them are the timing-chain constants that specify character-cell parameters; values for cursor definition, horizontal, and vertical timing; values for the character attributes and other display controls; values to determine character positions; and values that set the data rate, parity, full- or half-duplex transmission mode, etc.

After everything has been initialized, the program enters the character-processing loop, which is often referred to as the *main wait loop.* If a scanned keyboard is being used, scanning occurs every 10 milliseconds (ms) during this loop. When the hardware detects a character, a branching instruction passes control to the display-processing routine. (A more definitive explanation of keyboard scanning follows.)

Characters typed on a parallel-encoded keyboard are handled somewhat differently, as are characters received from the host computer or another terminal. When a character arrives from one of these sources, the hardware of the Term-Mite ST generates an interrupt, and control automatically passes into one of the interrupt-handling routines. In the case of the parallel keyboard, its data-strobe signal generates an external interrupt (an interrupt relying on hardware outside the processor); the interrupt handler causes the TMP to read the typed character from the I/O port, queue it for display, transmit it (if necessary), and return to wait for the next character.

When the hardware receives data on the serial input line, it generates

an internal interrupt. Control branches to several routines that determine what type of interrupt occurred and take appropriate action. The first test checks for received characters in the buffer of the UART (universal asynchronous receiver/transmitter). If a character is found in the buffer, it is queued for display (i.e., placed in the holding area for data to be shown on the screen). If no character is found, the register contents are tested for a match with the special value that indicates an empty-transmit-buffer condition, in which case the program tries to fill the transmit buffer. The final test is for the internal timer; timer interrupts happen every 10 ms and are used to trigger the keyboard scanning. If the Term-Mite ST is not set up to use a scanned keyboard, the internal-timer interrupt produces no activity.

Because of the operating differences between scanned and encoded keyboards, the control program contains two routines for reading a keyboard character. The encoded keyboards are handled by the external-interrupt routine. Very few processor instructions are required to fetch the character, since the data comes in from the I/O port already encoded as values in the ubiquitous ASCII (American National Standard Code for Information Interchange) character set established by ANSI (the American National Standards Institute). In contrast, getting a character from the scanned keyboard takes a fairly lengthy subprogram, which must examine the switch matrix of the keyboard for closures and convert that data into a meaningful ASCII character. The two keyboard routines, however, merge at the point where the character has been identified; a common section of code is used to display, transmit, and queue the character.

The display-processing subroutine is entered from the main wait loop when the program finds that the input-character buffer is not empty. If the character appearing in the buffer is part of an Escape sequence, the processing routine decides whether to wait for additional information (more characters) or to take immedi-

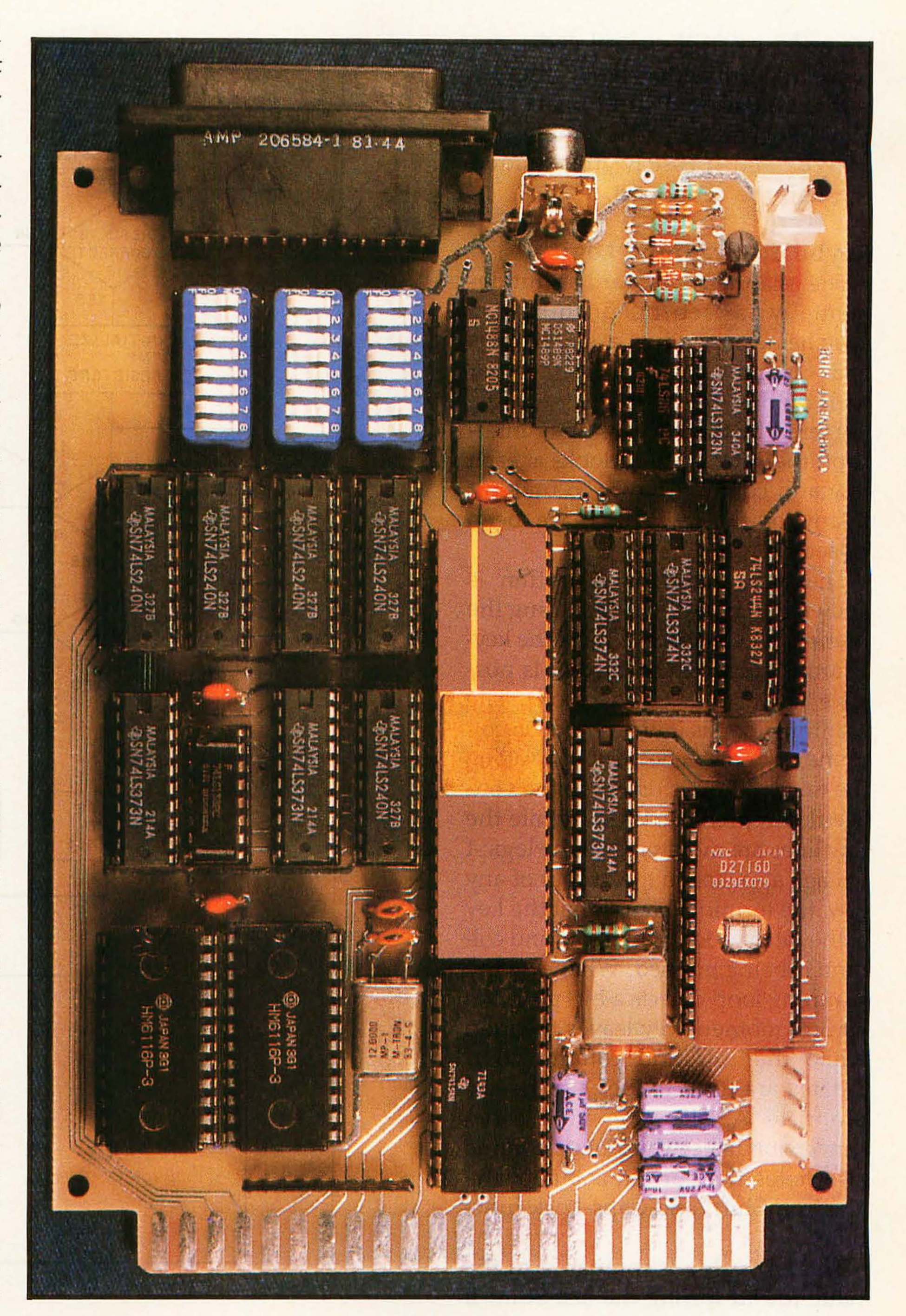


Photo 1: *A prototype of the Term-Mite ST circuit board, measuring only 4½ by 6½ inches. The design incorporates the National Semiconductor NS455A Terminal Management Processor.*

1. 24 lines of 80 characters each, uppercase and lowercase
2. supports either scanned or parallel-encoded keyboards
3. selectable data rate, parity, cursor, and display options
4. attributes: reverse-video, half-intensity, double-height, double-width, underlined, blinking and/or blanked character
5. line (block) graphics
6. 21 Escape functions
7. 14 control functions
8. twenty-fifth-line reverse-video status display
9. self-test
10. separated-sync or composite-video output

Table 1: *The features of the Term-Mite ST intelligent video-display terminal.*

ate action. ASCII control codes are processed immediately. If the received character is an ordinary displayable character, it is simply displayed and possibly transmitted through the serial port.

Keyboard-Scanning Logic

The scanned keyboard is fundamentally a set of push-button switches arranged in a set of rows and columns and wired together with diodes. Every 10 milliseconds, triggered by the internal-timer interrupt, the Term-Mite ST looks at each row and column in turn to find out if any of the switches have been closed.

The basic scanning algorithm is shown in figure 3. The first thing the routine does is check to see if the keyboard is currently enabled (it is possible to turn the keyboard off). The scanning loop is initialized for 16 columns of key switches. The wire along the first column is driven to the voltage that represents logic 1 while the row lines are monitored. If the logic-1 voltage appears on the output of any row, the terminal knows that the key at the intersection of that row and column is being pressed. Whenever the scanning loop detects a hit, program control momentarily leaves the loop while the row and column coordinates are used to look up the appropriate ASCII value in a code-conversion table. The lookup routine also notes the current status of the Control, Shift, and Caps-Lock functions.

The key value is compared to the value found during the last scan; if they are the same, the routine assumes that the key simply has not yet been released from the previous stroke and ignores the key-pressed condition. (When typing, most people hold down each key long enough for many scans to occur. Except when the Repeat key is in use, the terminal assumes that continued closure of the key switch should not produce further output.) If the scanning routine finds that the most recently read key value is indeed a new character, it stores the value and resumes scanning. If two key switches are found simultaneously closed in one column, the two characters are processed in turn before the scan is restarted.

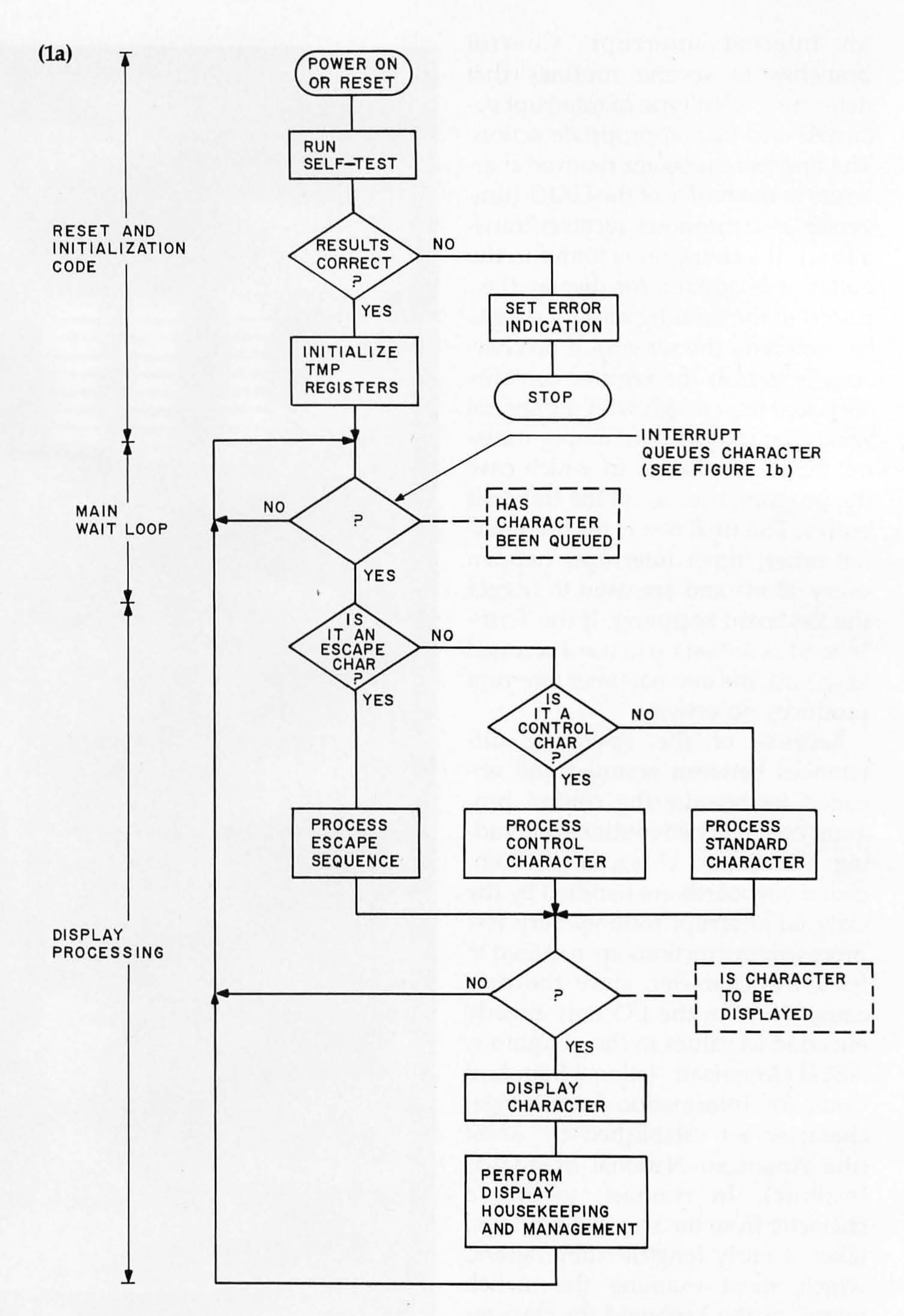
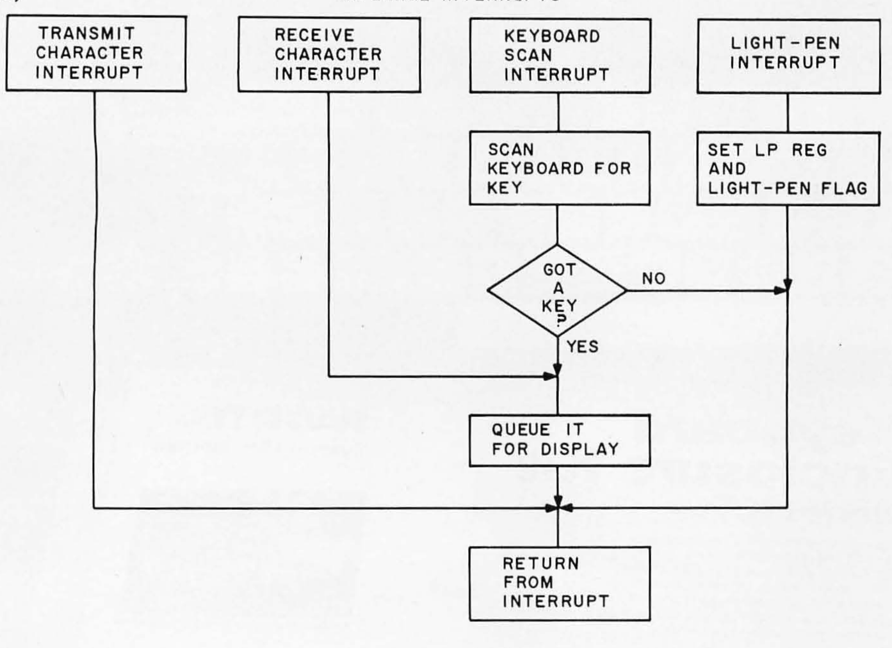


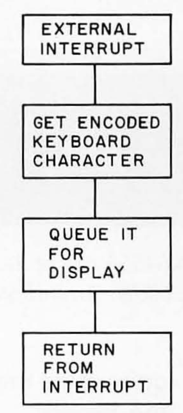
Figure 1: *A flowchart of the control program supplied standard by National Semiconductor for the NS455A. The main code is shown in 1a while the interrupt sections are in 1b.*

After all the columns have been scanned, the routine checks the character-value storage to see if any keys were pressed. If the number of "hits" found is greater than four, it exits with no output. Valid characters, produced by one to four key presses per scan, are queued in the keyboard buffer for display and output. The routine also checks the Repeat key; if it is being held down, the program initially delays 1 second and then begins to queue the same character again at intervals of 0.1 second. If no keys were detected during the scan, the program cleans out the keyboard-buffer storage area, resets the interrupt mask, does some housekeeping, and returns from the interrupt.

(Note: The keyboard-scanning rou-

(1b)





tine is somewhat hardware-dependent. A numeric keypad and separate input lines for Control, Shift, Repeat, and Caps-Lock keys may not be available or work the same way in all keyboards. The standard program is written to operate with an Oak full-travel membrane (FTM) keyboard. Other keyboards, including the one shown in photo 2, can be made to work with the standard NS455A, but the Oak keyboard can be used with a minimum of trouble.)

Configuring for Use

The biggest annoyance of today's advanced intelligent terminals is that they can be complicated to use. When you unpack a new unit you can expect to spend at least an hour trying to set the switches for all the proper optional modes and functions. At such times I fondly recall first plugging in my completed TV Typewriter in late 1973 (see references 2 and 4). There were no confusing configuration switches or Escape sequences. I just typed.

The Term-Mite ST, though small, was designed to be powerful, so it has to include some options that you set before use. I have tried to keep them as simple as is compatible with flexibility. These options are both hardware- and software-configurable.

In the Term-Mite ST, three eight-position DIP (dual-inline pin) switches let you set up the unit to assume certain operating conditions and parameters when you first turn it on. Once the terminal has been turned on, most of the switch-*preset* parameters can be changed by on-line commands received either from the keyboard or through the RS-232C port. In this same manner, some additional parameters that don't have switches can be set up. The commands are sequences of ASCII characters, either single nonprinting control codes or ordinary characters preceded by an Escape character (Escape sequences).

Control codes, as in most ASCII-encoded applications, are generated at the keyboard by simultaneously holding down the Control key and one other alphabetic or character key. The binary value emitted is within the special low range of ASCII codes designated for the control of devices. These codes do not normally cause any symbol to be printed or displayed, so they are referred to as *nonprinting*. A list of the control codes as used by the Term-Mite ST (running with the standard firmware) is shown in table 2 on page 96. An ASCII control code is often abbreviated by the corresponding printing character preceded by a caret or an up-arrow; thus "^G" stands for Control-G.

Escape sequences are more complex. These consist of characters that are mostly in the range of regular ASCII values, but the normally printable codes are transmitted following the special ASCII Escape character (decimal 27). This Escape character is so named because the characters that follow it "escape" from their normal meanings. (In the context of an Escape sequence, almost any meaning is possible for any character, although some Escape sequences are widely used, and one set has achieved the status of an ANSI standard equal to ASCII itself—see reference 1.) In the Term-Mite ST, an Escape sequence consists of at least two keystrokes: the Escape key followed by an uppercase letter (in the set A through Z, with some unused). The Escape sequences activate various functions of the Term-Mite ST. Only direct cursor addressing and the set-attribute-value function re-

Photo 2: *The Term-Mite ST can be connected to the stack-pole keyboard shown here, but the NS455A can be used more easily with an Oak full-travel membrane (FTM) keyboard from Oak Switch Systems Inc., POB 517, Crystal Lake, IL 60014. An enclosure from Pac Tec (Enterprise and Executive Aves., Philadelphia, PA 19153) enhances the terminal's appearance.*

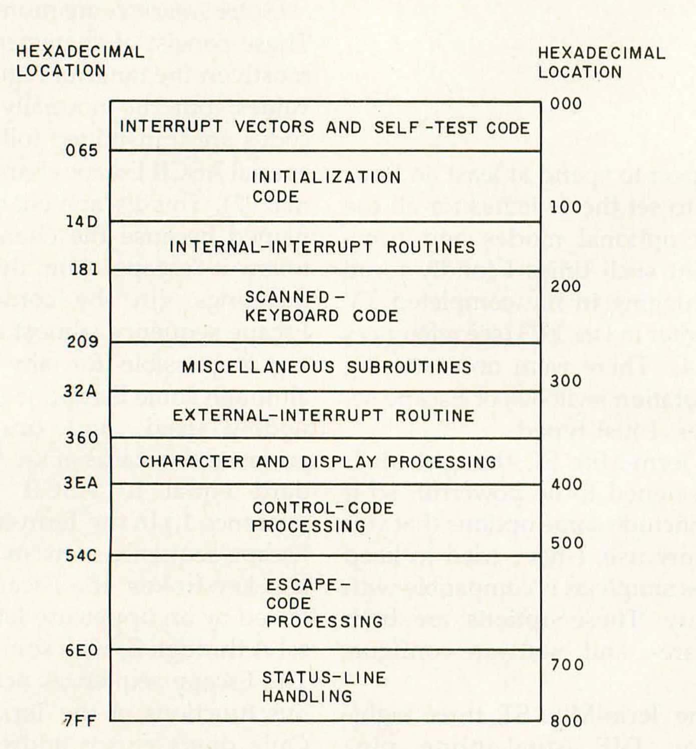


Figure 2: *Memory use by the NS455A control program.*

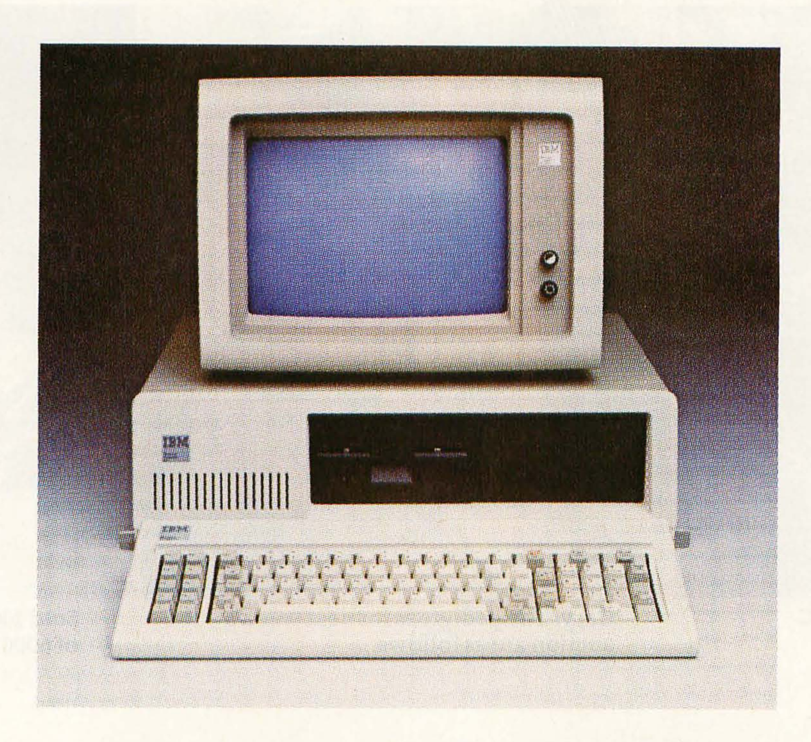
quire more than one character following Escape.

When power to the Term-Mite ST is first turned on, the three groups of *configuration switches* are read and their values stored in appropriate registers in the TMP. The switches appear to the processor as memory-mapped I/O devices; logic 1 is considered to be the on or closed position. (National Semiconductor's software refers to the groups as switches 4, 5, and 6, so I have used the same designations in the Term-Mite schematic.) Their configurations and various settings are shown in tables 4, 5, and 6 and in figures 4, 5, and 6.

Programming the Term-Mite

Your use of the Term-Mite ST can be simple or complex, depending on how you write your host software: to use the control commands and Escape sequences extensively or not

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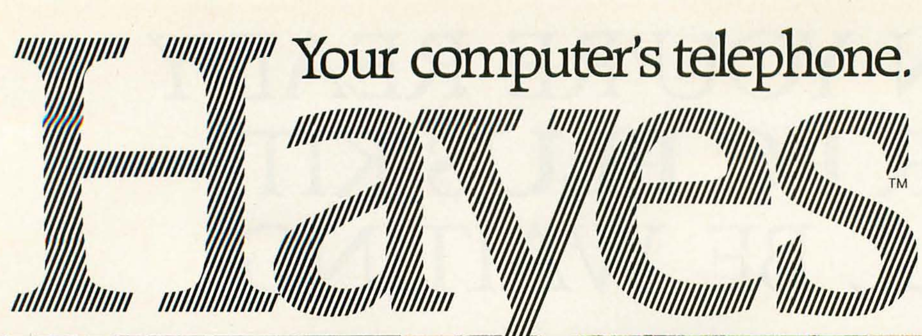
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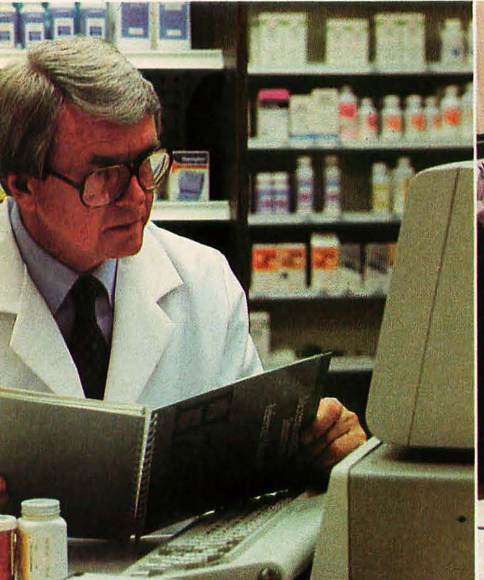


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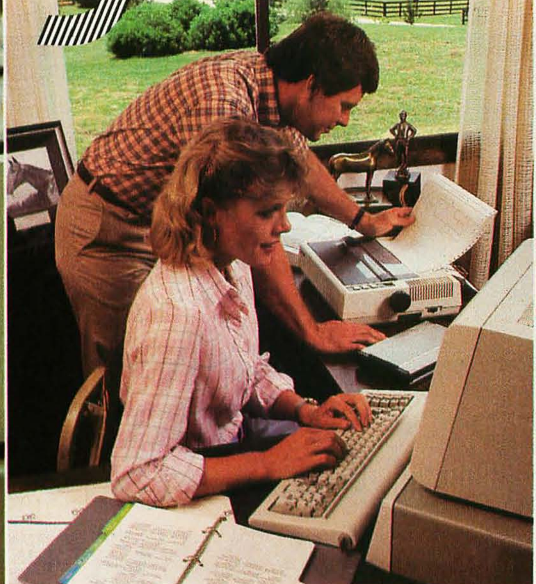
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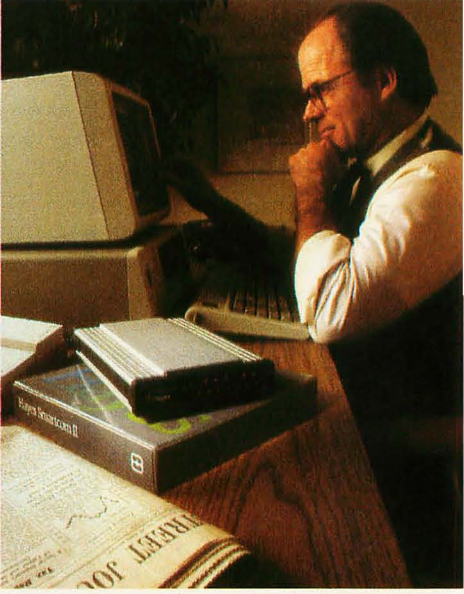




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Figure 3: *A flowchart of the keyboard-scanning routine.*

at all. If you just want to write BASIC programs, you'll probably never have to do more than use the default switch settings. If, however, you want to use the terminal as part of a screen-template inquiry-transaction system, you'll want to use all the character attributes and graphics options.

Some forms of the Escape sequences cannot be generated through the keyboard (ones with leading-zero attribute values, for example); these must be supplied by the host computer. One of the easiest ways to do this is to use the CHR$ function in BASIC, giving the decimal values of the required characters. I used a Radio Shack TRS-80 Model 100 portable computer to generate the displays depicted in the accompanying photos. With these few simple examples, I'll try to give you a feel for the use of the control functions. The communication protocol is peculiar to the Model 100, but the basic approach and much of the code can be used on other machines.

The first example is shown in listing 1 on page 102, a demonstration of displaying blinking characters. Lines 20 and 25 in this BASIC program clear the screen with a Control-L, then position the cursor at the sixteenth line with a sequence of the type ESC, M, *x*, *y*. An ESC, I, 251 sequence sets the blinking attribute for the single word "BLINKING" (attribute bit 2 set

Control Code	Effect
Control-G	*Ring the bell.* The ^G code causes a strobe pulse to be sent out bit 5 of the I/O port to trigger a 100-ms one-shot multivibrator, which can be connected to a piezoelectric transducer.
Control-H	*Backspace.* The destructive backspace moves the cursor to the left; the new position is blanked. Wrap-around occurs from line to line, including a screen wrap from the home (upper left) to last position.
Control-I	*Horizontal tab—fixed every eight locations.* The tab function is handled by the Tab key or by the ^I code. Each line is divided up into fixed eight-character tab zones. Each Tab received causes the cursor to jump from its current position to the start of the next tab zone, proceeding to the right. Screen scrolling occurs at the bottom of the screen.
Control-J	*Linefeed.* ^J is the standard ASCII Linefeed character.
Control-K	*Vertical tab—fixed every eight lines.* ^K moves the cursor down the screen eight rows. If the cursor is at the bottom of the screen, the display scrolls by eight lines. Intervening lines are always blanked. The cursor column *position always* remains the same after ^K; no carriage return is performed.
Control-L	*Clear screen and home the cursor.*
Control-M	*Standard ASCII Return character.* ^M moves the cursor to the leftmost column.
Control-N	*Cursor up.* The cursor is moved up one line by the ^N code. The movement is nondestructive, and the cursor will wrap around the screen from top to bottom when the top line is reached.
Control-O	*Cursor down.* Similarly, the cursor moves down one line, nondestructively, when ^O is detected. Again, wrap-around from bottom to top occurs.

Table 2: *The functions of ASCII control codes in the Term-Mite.*

Escape Sequence	Effect
ESC, A	*Auxiliary (printer) port on.* An ESC, A sequence will turn on the auxiliary printer port, if it exists (the port hardware is not implemented in Term-Mite). Everything displayed on the screen will go out the auxiliary port as well. Note that Return and Linefeed characters are not sent to the display routine unless the terminal is in Control mode. (All control characters are then put on the display graphically.) The "AUX ON" message is displayed on the status line when this Control mode is active.
ESC, B	*Display switch-register status in status line.* An ESC, B causes the UART configuration switch and data-rate code to be displayed on the status line.
ESC, C	*Control mode on.* An ESC, C sequence causes the unit to enter the Control mode. This mode of operation permits you to see all the normally nondisplayable ASCII characters (e.g., Return, Linefeed) on the display screen. The control characters are displayed as reverse-video, half-intensity uppercase letters. "A" through "Z" plus some punctuation are used. In addition, the message "CTL MODE" is displayed on the status line.
ESC, D	*Toggle on-line/local mode.* You can set the terminal to on-line or to local mode from the keyboard using this Escape sequence. It is a toggle function; i.e., each use causes the terminal to change from the current state to the other one. The status line also displays the current state.
ESC, E	*Toggle full-/half-duplex mode.* This is also a toggle function (see ESC, D) except that you can go from full-duplex (FDX) to half-duplex (HDX) communication and back. The terminal's current state is displayed on the status line.
ESC, F	*Control mode off.* ESC, F turns the Control mode off. The ASCII control characters now resume their normal operation and function. The message disappears from the status line.
ESC, G	*Set graphics mode on.* The ESC, G sequence flips the status line to normal video and enables the graphics attribute for characters specified in the AL1 register. This is the mode to use when doing forms drawing with the supplied terminal software. This state remains in effect until turned off by another Escape sequence (ESC, H).
ESC, H	*Set graphics mode off.* To turn off the graphics or line-drawing mode, the ESC, H sequence is used.
ESC, I, *v*	*Set Attribute Value.* You can set attributes to any combination by using the ESC, I, *v* sequence. If internal attributes are being used, the contents of AL1 are replaced with the 8-bit binary value *v*. When using external attributes, the value *v* is loaded into the current-attribute-value register. All subsequent characters will have this value loaded into their external attribute memory unless it is changed by another ESC, I, *v*. Bits are added together to obtain *v* for each combination of attributes as shown below. Attribute Bit — Attribute bit 7 — graphics bit 6 — blanked bit 5 — underlined bit 4 — double width bit 3 — double height bit 2 — blinking bit 1 — half intensity bit 0 — reverse video

Table 3: *The effects of Escape sequences in the Term-Mite ST.*

Control Code	Effect
Control-P	*Cursor left.* ^P moves the cursor left one column, nondestructively. Screen wrap-around from right to left will cause the cursor to move up a line each time the wrap-around occurs.
Control-Q	*Cursor right.* The fourth cursor-movement code is ^Q. The cursor moves right by one column, nondestructively, and screen wrap-around happens as above. Wrap-around moves down a line until the end of the screen is reached, and then the cursor moves back to the top of the screen. No scrolling is done.
Control-R	*Cursor home.* The ^R code moves the cursor to the home (uppermost left) position. Nothing else happens.
Control-S	*Send a "break" signal on serial line.* ^S generates a "break" signal (300 ms of "spacing" condition) on the RS-232C line.
Control-T	*Change and display data rate.* The data rate for the RS-232C lines can be changed via the ^T code. Each time ^T is entered, the data rate is displayed (in 00 to 15 code form) after being bumped to the next higher rate. Both receive and transmit rates are affected. They are as follows: 00 = 110 bps 01 = 134.5 bps 02 = 150 bps 03 = 300 bps 04 = 600 bps 05 = 1200 bps 06 = 1800 bps 07 = 2400 bps 08 = 3600 bps 09 = 4800 bps 10 = 7200 bps 11 = 9600 bps 12 = 19,200 bps 13 = 19,200 bps 14 = 19,200 bps 15 = 4800 bps

Escape Sequence	Effect
	A logic 0 in a bit position enables the corresponding attribute.
ESC, K	*Keyboard enable (X-on).* The keyboard can be selectively enabled or disabled. ESC, K performs the X-on or enable function.
ESC, L	*Return light-pen value.* An ESC, L sequence causes the currently latched values in the horizontal light-pen register (HPEN) and the vertical light-pen register (VPEN) to be transmitted back to the host system via the main RS-232C port. HPEN is sent (one binary character) followed by VPEN (also one binary character). Term-Mite does not support the light-pen hardware.
ESC, M, *x*, *y*	*Load cursor position (x,y).* The cursor position is dynamically alterable by means of this Escape sequence. The two parameters following the basic Escape code are used to set the *x* and *y* (respectively) positions of the cursor. The *x* value is the column position. Up to 79 columns are allowed. The *y* value specifies the row or line number, 0 through 23 being valid. The origin point is the home position on the screen (upper-left corner) and all the values are calculated as offsets from that point. The actual parameter values begin with the displayable ASCII character set, that is, blank through lowercase "o." To specify cursor position (5,6), for example, the parameters would be the two characters "%&" (hexadecimal 25 and 26). The 80 *x* values would run from blank (hexadecimal 20) through "o" (6F) and 24 *y* values from blank (hexadecimal 20) through "7" (37).
ESC, O	*Keyboard disable (X-off).* The ESC, O sequence disables the keyboard from further operation. This is essentially an X-off function. It must be reenabled by an ESC, K sent from the host system or entered from the keyboard itself.
ESC, P	*Print screen contents.* You can dump the entire displayed contents of the screen to the auxiliary or printer port by typing the ESC, P key sequence.
ESC, Q	*Run self-test diagnostic and reset.* ESC, Q causes the system to rerun the self-test and initialization routines. All current machine status conditions will be replaced by the power-on defaults. The current screen contents are lost.
ESC, R	*Block send the current row.* This is one of the Block Send commands. An ESC, R sequence causes the current line (from left margin to the cursor position) to be transmitted character by character to the host system. If the cursor is on the left margin (i.e., there's nothing on the line yet), nothing is transmitted.
ESC, S	*Block send the current screen.* The other Block Send command is ESC, S. This command transmits the data on the screen, character by character, from the home position to the current cursor location over the RS-232C link to the host system.
ESC, T	*Erase to end of line.* An ESC, T erases the current line from the cursor position to the right margin. It includes the cursor position in the erase operation.
ESC, W	*Wipe switch-register status from status line.* The switch-register and data-rate information can be wiped from the status line by entering ESC, W.
ESC, X	*Auxiliary port (printer) off.* This reverses the effect of ESC, A.
ESC, Y	*Erase to end of page.* You can erase the entire screen from the present cursor location to the end of the screen by typing ESC, Y. The present cursor location is included in the erase function.

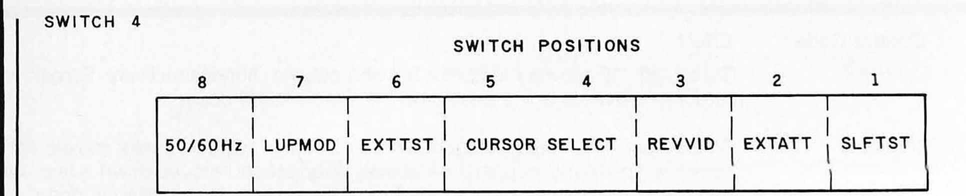


Figure 4: *The assignments of the switch positions in configuration switch 4. (Switches 1, 2, and 3 do not exist.)*

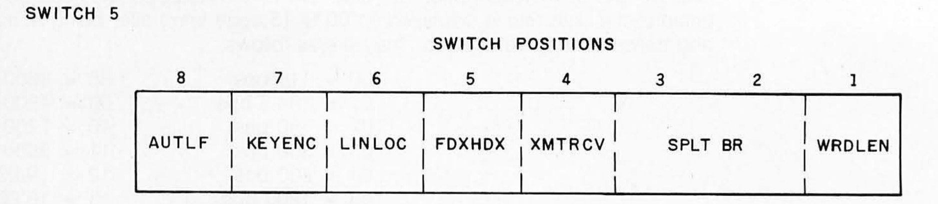


Figure 5: *The assignments of the switch positions in configuration switch 5.*

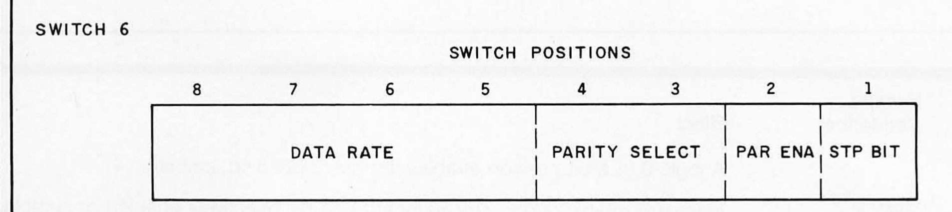


Figure 6: *The assignments of the switch positions in configuration switch 6.*

to 0). An ESC, I, 255 restores the normal character display for the final word.

Listing 2 functions in a similar manner to show off the reverse-video attribute. In this instance, the reverse-video attribute is activated by an ESC, I, 254 sequence (attribute bit 0 set to 0). The result is shown in photo 3a on page 108.

Listing 3 on page 104 combines four attributes. It starts by clearing the screen, positioning the cursor at column 21, row 6 (21,6), and printing "WE CAN PRINT THE REGULAR WAY"; next, the cursor is repositioned to (0,10) and the sequence ESC, I, 230 is sent. The value of 230 (bits 0, 3, and 4 set to 0) sets the double-width, double-height, and reverse-video attributes. Photo 3b on page 108 shows the appearance of the screen.

A few peculiarities do apply to the use of the double-width and double-height characters. The ASCII value of any character to be displayed in either or both of these attributes must be written in *all* the character positions that the expanded character will occupy. For example, if you wish to print "TEST" in double width, the BASIC PRINT statement should actually send the string "TTEESSTT", since the wide characters will occupy two regular character positions. In double height, the duplicate characters should be written one above the other. The other catch to using double height is that the second row of characters must also have the *blanked* attribute set. In the example of listing 3, with the attributes set for double height, double width, reverse video, and (on the second display line) blanked, the string "OR THIS WAY FOR SPECIAL EMPHASIS" is printed in large letters. After the pyrotechnics, another Control-I is used to reset the attributes.

One final demonstration program, shown in listing 4, shows many of the characteristics already mentioned with the addition of line graphics.

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Switched Signal	Effect
50/60 Hz	Because the NS455A is designed for worldwide distribution, provision has been made for handling operation at either 50 Hz or 60 Hz. A logic 1 specifies 60 Hz, while a logic 0 sets 50-Hz operation.
LUPMOD	This bit affects the loop-back mode of the serial I/O line. When it is 0, the serial output line is logically connected to the serial input line inside the chip. A logic 1 sets the serial line to normal mode.
EXTTST	The external test flag is used to force a jump to external memory located at hexadecimal address 800. This test is only made if SLFTST is also selected. The author of the self-test code must take care of either returning to the supplied standard program or handling all processing from that point on.
CURSOR SELECT	There are four types of cursors that can be selected on the Term-Mite: a solid underline, a blinking underline, a solid block, or a blinking block. The binary codes are as follows: 00 = solid underline cursor 01 = blinking underline cursor 10 = solid block cursor 11 = blinking block cursor
REVVID	A logic 0 will cause the display to switch to black characters on a white field. The default value of logic 1 specifies normal video, white on black.
EXTATT	A 0 in this position lets you use the external attribute memory, bits 8 through 15. A logic 1 sets the system up for internal attributes.
SLFTST	A logic 1 in this bit causes the self-test routine to be skipped on reset or power up. It must be set to logic 0 in order for the self-test to be performed. This does not affect the ESC, Q command to execute a self-test.

Table 4: *The functions of the switch positions in configuration switch 4.*

Switched Signal	Effect
AUTLF	This is the Auto-Linefeed flag. When set to a logic 0, a Linefeed character is sent whenever a Return character is detected. This operates for both the transmitted data and the displayed information. A logic 1 causes no Linefeed to be sent.
KEYENC	The encoded keyboard is selected by a logic 0. A logic 1 indicates that the scanned keyboard is to be handled.
LINLOC	This is the Online/Local default. When this flag is set to logic 0, Local mode is chosen, and no data is sent to the host machine. A logic 1 puts the terminal into Online mode and data is then transmitted.
FDXHDX	The full-duplex/half-duplex flag is used to set the communication protocol. When set to logic 0, the communication through the serial port is half duplex; data is both transmitted to the host and sent to the CRT display. A logic 1 will select full duplex. Data is then transmitted but not automatically sent to the display.
XMTRCV	The split-data-rate function uses this flag to decide whether the transmitter (logic 0) or the receiver (1) is to operate at the slower data rate.
SPLT BR	This field sets the split-data-rate divisor to one of four values. The divisor divides the affected rate by a factor of 1, 4, 16, or 32. More divisors are allowed, but they are not implemented in the standard program. 00 = divide by 32 10 = divide by 4 01 = divide by 16 11 = divide by 1 (default)
WRDLEN	The word-length flag specifies the number of bits in the serial character, either 7 or 8 bits excluding parity. A default of 1 selects 7 bits, and a logic 0 selects 8 bits.

Table 5: *The functions of the switch positions in configuration switch 5.*

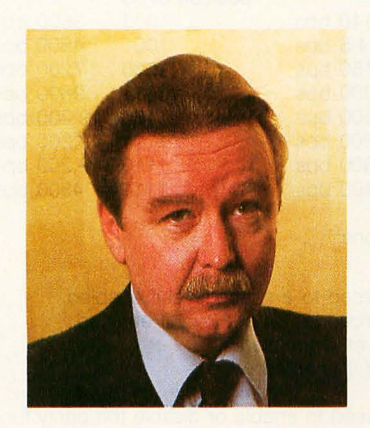
When attribute bit 7 is set to a 0, the Term-Mite displays certain control characters as graphic symbols. These are shown in table 8 on page 108. The program draws the display shown in photo 4.

In Conclusion

Since building the Term-Mite ST, I've been finding all kinds of old and new uses for it. For instance, it makes a perfect status and command display for a Micromint Z8-BASIC Computer/Controller system (see reference 3). Also, I've been hesitating to spend $1000 for a regular video terminal that would be dedicated to a constant display of the time of day and my appointment schedule, but

Text continued on page 108

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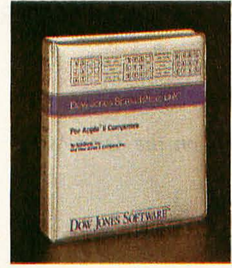
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Communication Parameter	Explanation
DATA RATE	Four bits select the data rate used by the serial-I/O section. The available rates are shown below:

position 8765		position 8765	
0000	110 bps	1000	3600 bps
0001	134.5 bps	1001	4800 bps
0010	150 bps	1010	7200 bps
0011	300 bps	1011	9600 bps
0100	600 bps	1100	19,200 bps
0101	1200 bps	1101	19,200 bps
0110	1800 bps	1110	19,200 bps
0111	2400 bps	1111	4800 bps

PARITY SELECT — There are four parity options:

position 43
11 = Parity is forced to a space level if enabled.
10 = Parity is forced to a mark level if enabled.
01 = Parity is even if enabled.
00 = Parity is off if enabled.

PARENE — The parity-enable flag is used to enable or disable the parity function. If the switch is a 0, parity is disabled. A value of 1 enables parity.

STPBIT — This flag specifies the number of stop bits to be sent with each character. A logic 1 will cause one stop bit to be sent; a 0 will send two stop bits.

Table 6: *The functions of the switch positions in configuration switch 6.*

Switch 4	Switch 5	Switch 6
11111100	10100111	00111010

Table 7: *For general use, typical settings of all three switches might be as shown here (most significant bits to the left).*

Listing 1: *A BASIC program to produce blinking characters on the Term-Mite.*

```
10 OPEN "COM:38N1D" FOR OUTPUT AS 1
20 PRINT #1,CHR$(12):REM CLEAR SCREEN
25 PRINT #1,CHR$(27);"M0+"
30 PRINT #1,"THIS IS HOW WE PRINT IN ";
40 PRINT #1,CHR$(27);"I";CHR$(251);"BLINKING ";
50 PRINT #1,CHR$(27);"I";CHR$(255);"CHARACTERS"
100 CLOSE #1
110 STOP
```

Listing 2: *A program to produce reverse-video characters on the Term-Mite.*

```
10 OPEN "COM:38N1D" FOR OUTPUT AS 1
20 PRINT #1,CHR$(12):REM CLEAR SCREEN
25 PRINT #1,CHR$(27);"M0+"
30 PRINT #1,"THIS IS HOW WE PRINT IN ";
40 PRINT #1,CHR$(27);"I";CHR$(254);"REVERSE VIDEO ";
50 PRINT #1,CHR$(27);"I";CHR$(255);"CHARACTERS"
100 CLOSE #1
110 STOP
```

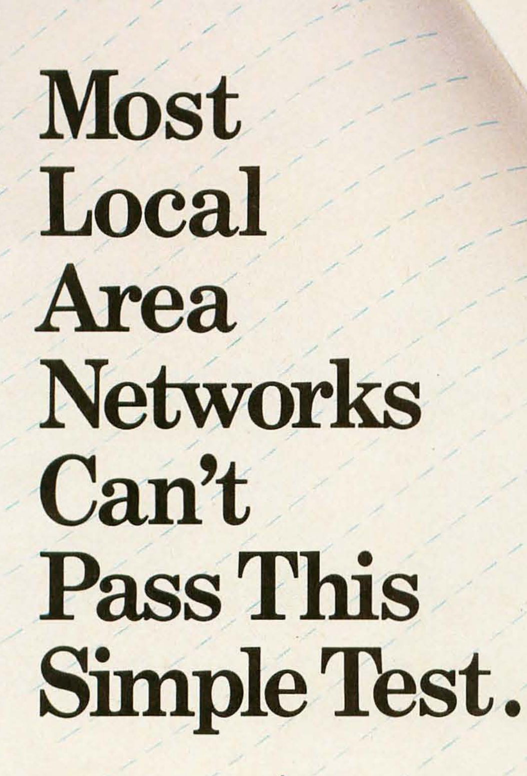
Listing 3: *A BASIC program to demonstrate reverse-video, double-height, double-width characters on the Term-Mite.*

```
10 OPEN "COM:38N1D" FOR OUTPUT AS 1
20 PRINT #1,CHR$(12):REM CLEAR SCREEN
25 PRINT #1,CHR$(27);"M5&";
30 PRINT #1,"WE CAN PRINT THE REGULAR WAY"
40 PRINT #1,CHR$(27);"M *";CHR$(27);"I";CHR$(230);
50 PRINT #1,"OORR  TTHHIISS  WWAAYY  FFOORR  SSPPEECCIIAALL  EEMMPPHHAASSIISS"
60 PRINT #1,CHR$(27);"M +";CHR$(27);"I";CHR$(166);
70 PRINT #1,"OORR  TTHHIISS  WWAAYY  FFOORR  SSPPEECCIIAALL  EEMMPPHHAASSIISS"
80 PRINT #1,CHR$(27);"I";CHR$(255)
90 CLOSE #1
100 STOP
```

Listing 4: *A program to demonstrate all internal character attributes and the drawing of borders with line-graphics characters.*

```
10 OPEN "COM:38N1D" FOR OUTPUT AS 1
20 PRINT #1,CHR$(12)
30 PRINT #1,CHR$(27);"I";CHR$(127)
35 PRINT #1,CHR$(27);"M%#";
50 PRINT #1,STRING$(70,23)
60 PRINT #1,CHR$(27);"M$*";
70 PRINT #1,STRING$(71,23)
80 PRINT #1,CHR$(27);"M$-";
90 PRINT #1,STRING$(71,23)
100 PRINT #1,CHR$(27);"M$5";
110 PRINT #1,STRING$(71,23)
120 FOR I% = 3 TO 21
130 PRINT #1,CHR$(27);"M$";CHR$(32+I%);
140 PRINT #1,"J"
150 PRINT #1,CHR$(27);"Mk";CHR$(32+I%);
160 PRINT #1,"J"
170 NEXT I%
180 FOR I% = 10 TO 13
190 PRINT #1,CHR$(27);"M5";CHR$(32+I%);
200 PRINT #1,"J"
210 PRINT #1,CHR$(27);"MG";CHR$(32+I%);
220 PRINT #1,"J"
230 PRINT #1,CHR$(27);"MY";CHR$(32+I%);
240 PRINT #1,"J"
250 NEXT I%
251 PRINT #1,CHR$(27);"M$#X";CHR$(27);"Mk#L";
252 PRINT #1,CHR$(27);"M$5";CHR$(21);CHR$(27);"Mk5";CHR$(22);
253 PRINT #1,CHR$(27);"M$*";CHR$(28)
```

Listing 4 continued on page 106



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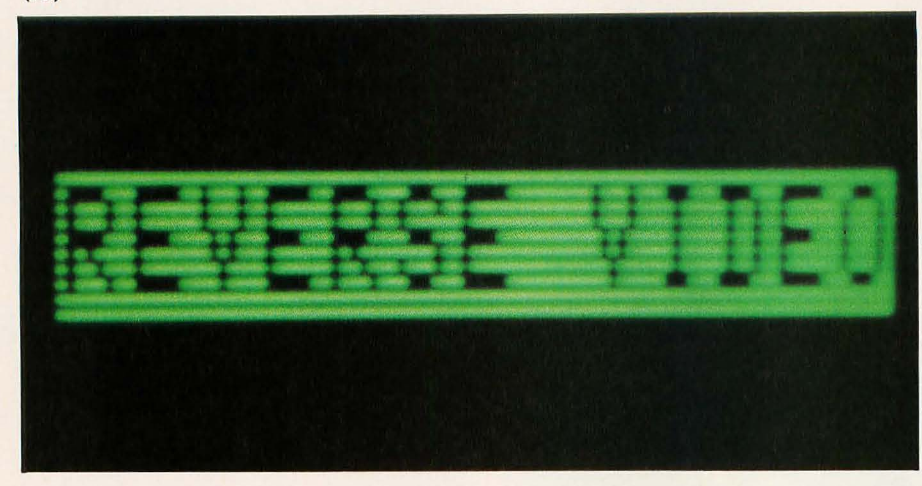
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```
254 PRINT #1,CHR$(27);"Mk*";CHR$(29)
255 PRINT #1,CHR$(27);"M$-";CHR$(28)
256 PRINT #1,CHR$(27);"Mk-";CHR$(29)
257 PRINT #1,CHR$(27);"M5*";CHR$(31);CHR$(27);"M5-";CHR$(30)
258 PRINT #1,CHR$(27);"MG*";CHR$(31);CHR$(27);"MG-";CHR$(30)
259 PRINT #1,CHR$(27);"MY*";CHR$(31);CHR$(27);"MY-";CHR$(30)
260 PRINT #1,CHR$(27);"I";CHR$(255)
270 PRINT #1,CHR$(27);"MF%";
280 PRINT #1,"THE"
285 PRINT #1,CHR$(27);"I";CHR$(231);
290 PRINT #1,CHR$(27);"M='";
295 PRINT #1,"TTEERRMM--MMIITTEE  SSTT"
300 PRINT #1,CHR$(27);"I";CHR$(167);
305 PRINT #1,CHR$(27);"M=(";
310 PRINT #1,"TTEERRMM--MMIITTEE  SSTT"
315 PRINT #1,CHR$(27);"I";CHR$(251);
320 PRINT #1,CHR$(27);"M*+";
325 PRINT #1,"BLINK"
330 PRINT #1,CHR$(27);"M(,";
335 PRINT #1,"ATTRIBUTE"
340 PRINT #1,CHR$(27);"I";CHR$(223);
345 PRINT #1,CHR$(27);"M:+";
350 PRINT #1,"UNDERLINE"
355 PRINT #1,CHR$(27);"M:,";
360 PRINT #1,"ATTRIBUTE"
365 PRINT #1,CHR$(27);"I";CHR$(253);
370 PRINT #1,CHR$(27);"MJ+";
375 PRINT #1,"HALF INTENSITY"
380 PRINT #1,CHR$(27);"ML,";
385 PRINT #1,"ATTRIBUTE"
390 PRINT #1,CHR$(27);"I";CHR$(254);
395 PRINT #1,CHR$(27);"M";CHR$(92);"+";
400 PRINT #1,"REVERSE VIDEO"
402 PRINT #1,CHR$(27);"M";CHR$(92);",";
404 PRINT #1,"  ATTRIBUTE  "
406 PRINT #1,CHR$(27);"I";CHR$(255);
408 PRINT #1,CHR$(27);"M)/";
415 PRINT #1,CHR$(27);"M00";
425 PRINT #1,CHR$(27);"I";CHR$(239);
430 PRINT #1,CHR$(27);"M'3";
435 PRINT #1,"DDOOUUBBLLEE  WWIIDDEE,,";
440 PRINT #1,CHR$(27);"I";CHR$(247);
445 PRINT #1,CHR$(27);"M@2";
450 PRINT #1,"DOUBLE HEIGHT,"
455 PRINT #1,CHR$(27);"I";CHR$(183);
460 PRINT #1,CHR$(27);"M@3";
465 PRINT #1,"DOUBLE HEIGHT,"
470 PRINT #1,CHR$(27);"I";CHR$(255);
475 PRINT #1,CHR$(27);"MO3";
480 PRINT #1,"and";
600 PRINT #1,CHR$(27);"I";CHR$(231);
605 PRINT #1,CHR$(27);"MS2";
610 PRINT #1,"DDOOUUBBLLEE  SSIIZZEE"
615 PRINT #1,CHR$(27);"I";CHR$(167);
620 PRINT #1,CHR$(27);"MS3";
625 PRINT #1,"DDOOUUBBLLEE  SSIIZZEE"
630 PRINT #1,CHR$(27);"I";CHR$(231);
650 PRINT #1,CHR$(27);"I";CHR$(191);
655 PRINT #1,CHR$(27);"MB";CHR$(34);"BLANK FAILURE";
660 PRINT #1,CHR$(27);"MG7";CHR$(27);"I";CHR$(255);
665 CLOSE 1
670 STOP
```





(3b)

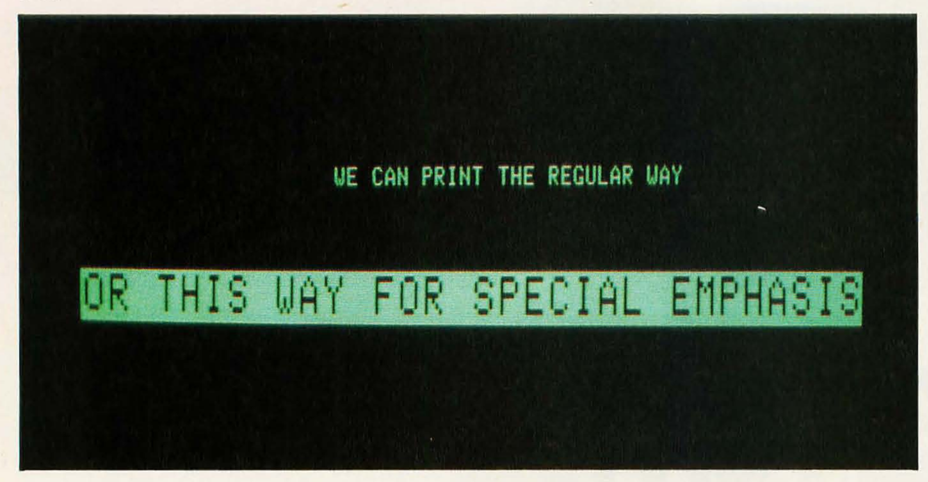


Photo 3: *The Term-Mite can display several character attributes singly or in combination, such as reverse video (3a) and reverse, double width, double height (3b).*

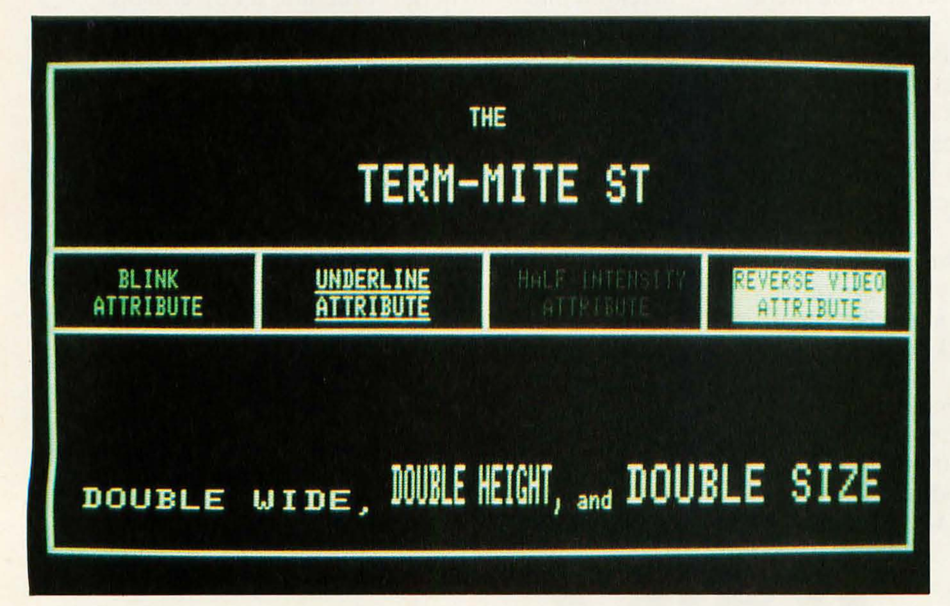
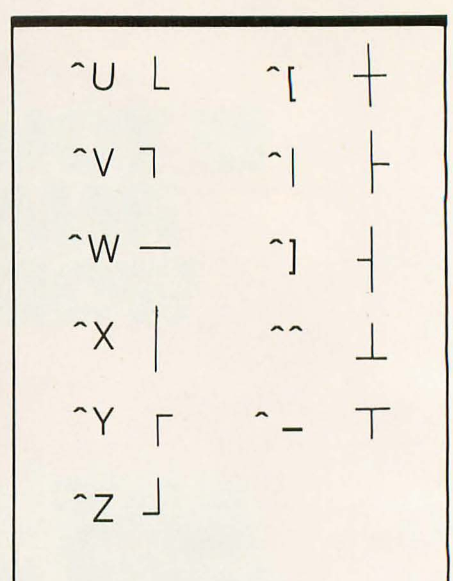


Photo 4: *The Term-Mite can display certain control characters such as line-graphics symbols for screen templates and other basic uses. This display was produced by the program of listing 4.*



^U	└	^[	┼
^V	┐	^|	├
^W	─	^]	┤
^X	│	^^	┴
^Y	┌	^_	┬
^Z	┘		

Table 8: *In the line-graphics mode, certain control characters produce visible displays of corners, lines, and crosses useful for forming borders on the screen display (^^ is Control-Caret).*

Text continued from page 100:

I can see using the Term-Mite's graphics and attributes for this and other applications. (I already have eight cathode-ray tubes staring at me in the Circuit Cellar. What's one more?)

Perhaps by building the Term-Mite you can put to good use that bargain keyboard and old monitor you've had sitting around for years. Be warned, however, that the unit's 25-line by 80-column display requires too great a bandwidth for satisfactory connection to a regular TV set. A 12-MHz monochrome monitor is the better choice, as shown in photo 5.

Since the Term-Mite's control software is stored in what is actually an EPROM (an erasable programmable ROM), it would be possible to add commands or modify the operation of its functions. National Semiconductor will eventually have complete documentation available for the NS455A TMP, including a listing of the standard supplied control program and the processor's instruction set. Within the 6K yet-unused bytes of program address space, some pretty fancy terminal software could be written, perhaps even to emulate the command protocols of various commercially sold terminals. The only



Photo 5: *The Term-Mite ST circuitry described in these articles is used with a separate keyboard and video monitor to form a complete functional terminal. Here a Jameco JE610 keyboard works with the Term-Mite, a NEC (Nippon Electric Company) green-phosphor monitor, and the Circuit Cellar MPX-16 computer.*

modification would be a simple EPROM change.

Next Month:

A new chip from Silicon Systems Inc. has prompted another project on speech synthesis. ■

Editor's Note: *Steve often refers to previous Circuit Cellar articles as reference material for each month's current article. Most of these past articles are available in reprint books from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08250.*

Ciarcia's Circuit Cellar, Volume I *covers articles that appeared in BYTE from September 1977 through November 1978.* Ciarcia's Circuit Cellar, Volume II *contains articles from December 1978 through June 1980.* Ciarcia's Circuit Cellar, Volume III *contains articles from July 1980 through December 1981.* Ciarcia's Circuit Cellar, Volume IV, *soon to appear, will contain articles from January 1982 through June 1983.*

Special thanks to Bob Harbrecht of National Semiconductor Corporation for his help on this project.

Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronic engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, product development, and marketing. In addition to writing for BYTE, he has published several books. He can be contacted at POB 582, Glastonbury, CT 06033.

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2. Ciarcia, Steve. "Build the Circuit Cellar Term-Mite ST Smart Terminal, Part 1: Hardware Description." BYTE, January 1984, page 37.
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4. Lancaster, Don. "TV Typewriter." *Radio Electronics,* September 1973, page 43.

To receive a complete list of Ciarcia's Circuit Cellar project kits available from the Micromint, circle 100 on the reader service inquiry card at the back of the magazine.

The following items are available from:

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Chaos Manor Gets Its Long-Awaited IBM PC

Of mice and men, Eagles, Shirley, the ol' mailbag, and much more

by Jerry Pournelle

Well, the big news is that our IBM PC arrived two days before Halloween. We had paid for it in June, and even after IBM notified us that it had been shipped to the local Computerland there were some, uh, interesting escapades suggesting shuffle and jive, but we do have it. Alas, within days we had major problems.

First, the video monitor developed a high-pitched whine from the flyback transformer. That soon became intolerable. Computerland in Woodland Hills gave us no difficulty at all; we returned the monitor, and they loaned us a replacement and sent ours off somewhere to be fixed.

We bought a bare-bones PC, one disk drive, and 64K bytes of memory. As soon as we got it, we added memory chips, bringing the PC's internal memory up to a full 256K bytes. The memory chips are available for about $7 each. It takes 27 of them (in blocks of nine; eight 1 by 64K bytes for memory, and one more for parity checking), so the upgrade will cost you $189; IBM charges a *lot* more.

It turns out there's no trick at all to adding the chips. You have to take the PC apart, but that's a simple matter requiring no tools but a Phillips screwdriver. (Our friend Noor Singh calls the two kinds of screwdrivers "plus" and "minus.") Then you have to adjust a couple of switches. The IBM system manual—the one you get whether you want it or not—not only tells you what switches to throw, but shows you a picture. You'd have to be pretty dense not to understand.

Indeed, there's a good solid feel to everything about the IBM PC. My initial impression is that I still prefer the Eagle 1600, but I must admit: the IBM screen is rock steady, the character set is aesthetically pleasing, and the keyboard has a pretty good feel even if the layout is rotten.

However, a day or so after we added the memory chips, the PC stopped working.

The IBM PC does a memory test whenever you turn it on. If it finds a memory error, it tells you "PARITY ERROR 1" and refuses to do anything else. There are no programs to tell you *which* memory chip is defective. Since we'd added a lot of memory chips, we figured chances were good that one of ours wasn't working.

It's a fair amount of work to swap out chips one at a time until the bad one is located; it would be much easier if we could figure out which bank the bad chip was in. The IBM manuals carefully explain how to set the internal switches to tell the machine how much memory it has available, which suggested a simple solution to our problem. We simply set those switches to indicate there was *no* additional memory, in other words, that the PC had aboard only the soldered-in 64K bytes that it came with.

On power-up we got the same PARITY 1 error. Since we couldn't possibly swap out the soldered-in chips, out to Woodland Hills Computerland went our PC.

They had it fixed the next day. Seems it was one of our chips.

"How can that be?" I asked. "We set the switches to eliminate that memory." Woodland Hills Computerland fixed the machine for us, but they had no answer.

Time to dig, so I called my sane friend, the one who's an IBM engineering executive. I explained the problem.

"It just could be that the new ROMs don't pay much attention to those switches," he said with a chuckle. "When they changed from 16K-byte to 64K-byte memory chips, they switched motherboards. What you have is an XT board in a normal PC."

Which is another undocumented feature. I wonder how many more I'll discover in my long-awaited PC?

Meanwhile, the undocumented feature brought about another problem. As regular readers of this column must know, I have no great

love for the IBM PC keyboard layout with its silly "\" key where the Shift key ought to be and the Return key way over where I can't reach it. The IBM Selectric keyboard is the world's best, bar none; why did they have to muck up success? But they did.

Fortunately, there's a remedy. Jim Baen's Magic Keyboard program reassigns those keys, turning the "\" into Shift, and the "~" (tilde) into Return and such like. To get the "\" and the squiggle back, use the Alt key. The result is that I end up with a Selectric keyboard layout, which is what I want. Magic Keyboard is nearly invisible and can be made to run on start-up; it takes a lot of the sting out of the PC.

However, although Magic Keyboard works fine on older IBM PCs, it wouldn't work with mine!

In a little-publicized move, IBM stopped putting 16K-byte chips in the PC and used 64Kers instead, which is why we could get 256K bytes on the motherboard. What IBM did was use a modified PC XT motherboard. This means that software (like Magic Keyboard) designed for *just* the PC won't work; you must use XT-specific software (MagicXT). I don't know if anyone else wrote software that specific; it was necessary for M.K. The good news is that MagicXT works fine, and you get both when you buy Magic Keyboard from Workman.

Other First Impressions

There are things to recommend the PC and even MS-DOS. There are machines that are built as well (Eagle), machines with better keyboards (both Eagle and TI PC), and machines that run faster (Eagle and Compupro), but no other with those magic initials.

Screen: the black-and-white screen is rock steady and the character set is pleasing.

Expansion: we already have three boards in our PC, and we haven't even got started yet. No wonder the breadbasket boards sell so well. Getting a 512K-byte board will bring your memory up to its theoretical maximum. I don't know if the PC won't address more, or if the 768K-byte limit is artificial.

Disk drive: we bought a PC with a single disk drive. It's built by Control Data Corporation (CDC) and it's very quiet and nice. Then we went to Priority One and bought a Tandon drive, which plugged in and ran with no trouble; but it's much more noisy than the one IBM supplied. I'm told that IBM is no longer using Tandon drives. Ours was cheap and works fine, though.

Software: we bought both DOS 1.1 and 2.0. Everything that runs on 1.1 is supposed to run on 2.0; we'll see if that's true. You also get a disk of diagnostic programs with DOS 2.0, but alas, ours was defective; it wouldn't copy ("Unrecoverable Read Errors"), it wouldn't boot, and it wouldn't run. Fortunately, my IBM engineer friend was able to supply me with a copy of his diagnostics disk.

When I tried to copy my defective disk, it reported "8 sectors/track," but when I copied his (known working) diagnostics disk, it reported "9 sectors/track." However, it boots and runs. The first time I ran the diagnostics, it reported a CRC error on the main drive and some other error on the new Tandon drive. The diagnostic program has an option to let it run forever, stopping only for errors; I set it up to do that, and Lo!, it ran for hours without errors, except for one "Error Keyboard 301" that was never repeated. There were no more drive errors.

I presume there was something spurious about those early errors, but it's one more thing to annoy us.

My son Alex wants to call our PC Lucy Van Pelt because it's a definite fussbudget. Two major repairs in a week! Plus a defective master disk, spurious errors, and we had to wait for it for four months after we paid.

Alex's Notes

Alex, a senior in computer science at UCSD, had a few hours to play with the IBM PC. Here are his notes.

"There is no honest-to-Krelden reset switch. You can press three keys together (Ctrl, Alt, and Del) and sometimes get out of situations, but not always, as for instance with that defective diagnostics disk. Otherwise, you must turn off the power, wait 10 to 20 seconds (there's a timer or something), turn it back on, wait through the self-check (up to 90 seconds), reload, etc. This can be a comprehensive drag on large programs.

"Memory checks are nice, but they can take a long time. With no Reset button, some way to defeat the memory check, or at least a faster memory check, would be nice. It'll be even worse when we have 768K."

The Logitech Mouse

We've also fired up Concurrent CP/M, which works, and connected the Logitech mouse, which also works; you just plug it in. Alex's comment is,

"The Logimouse is neat. I *will* have to experiment with it awhile to see about setting the push keys for different things. You can rerun a command just by moving the mouse; through experimentation I discovered that the arrow keys will do the same thing, so it must be a MS-DOS function. Anyway, the mouse currently writes arrow keys as if the keyboard did them; this is real nice in Lotus 1-2-3 and such. I'll want to scale the mouse's movement more since it's too sensitive."

I'm quite pleased with the Logimouse, although, as Alex says, it's scaled a little too fast. However, changing that is no problem at all. Moreover, the three buttons on the mouse can be set to make any characters you want, such as carriage returns or spaces or periods (for games) or any of the user-defined functions. You can set them so that more than one character per key is sent, too. Even better, the MS-DOS SUBMIT facility—that is, the ability to set up a chain of programs that run automatically with a single command—is pretty good, so that you can include a Logimouse redefinition in it.

A SUBMIT file (named AUTOEXEC.BAT, for batch) can be run on start-up. This means we can have the machine ask who has turned it on, and adjust the mouse commands to suit the user! We can also include mouse redefinitions in a SUBMIT file to invoke just about any program,

such as Lotus 1-2-3, games, or word processors, making the mouse buttons do what you'd want them to do in that particular context. This deserves a bit more thought; more next month. The bottom line is I like the Logimouse quite a lot.

That's a bit of a surprise, because I didn't think I'd like mice all that much. There are two generic problems with mice: (1) you need a clean, flat surface near the keyboard, and (2) you have to take your hands off the keys to use the mouse.

Number (1) is a problem in Chaos Manor; there are *no* clean, flat surfaces of any size, near the keyboard or away from it. It's a law of nature: a flat surface collects papers. As for (2), taking your hands off the keyboard can be a nuisance, but not when you've written the text and merely want to edit.

I do wonder: why hasn't someone developed a keyboard with a small thumb ball along one edge? You could move your hand to the thumb ball to drive the cursor; and there could be two or three buttons, of the mouse kind, where your fingers naturally rest when you've put your hand on the thumb ball. I'd sure like a keyboard like that. . . .

Coming Attractions

At present our PC is in need of expansion cards and the like, all of which we intend to add, after which comes a full report. I've also had a call from Steve Ciarcia about his wonderful new Quicksilver card and program; he's sending me one Real Soon Now, as soon as there's one available. As I said last month, Steve's card is the first thing one ought to add to an IBM PC, and I don't say that because Steve's a friend and colleague; it's a brilliant idea that makes your IBM PC into a new—and much faster—machine. More on that when I have a test model.

The Eagle Flies Again

We love our Eagle 1600. We truly do. It's faster than the IBM PC, and the keyboard is laid out better. It has a nice screen. The microprocessor chip is an 8086, which gets data 16 bits at a time. Compare this to the

IBM PC's 8088, which only gets 8 bits a shot. When we all go to concurrent operating systems—as we will—each of the four tasks and an 8086 system will run faster than the same job by itself on the PC's 8088.

The Eagle has on-board sockets for 512K bytes of memory and capability for multiple users. It also has eight expansion slots, same as the IBM PC XT. There's an optional built-in 10-megabyte hard disk.

It also has the lousiest documentation this side of the junkyard.

Marty Massoglia is programming the Inferno game (by Larry Niven and Jerry Pournelle) in Pascal MT+86 on PC-DOS. There came time to bring some of his results home.

The Eagle has one Winchester hard disk and one floppy disk. As everyone knows, floppy disks come in a number of formats and flavors. The IBM, for example, has floppy disks with 40 tracks per side. So does the Zenith Z-100, which is what I intended to test Marty's game software with. The Eagle's floppy has 80 tracks. Now 80-track disk drives can read and write to 40-track disks; thus we formatted a disk in the Z-100 and copied the files from the Eagle's hard disk onto the Zenith 40-track disk.

The Zenith couldn't read the files. It read the directory, all right, and it read some of the files, but we kept getting read errors.

Call Eagle. New discovery.

Sengle has the ability to format 40-track disks in its 80-track drives. You merely use the /i option when you give it the FORMAT command. This is known as an undocumented feature. It's about the tenth undocumented feature we've discovered for the Eagle. When we let the Eagle format its own 40-track disks, all worked fine, and the Zenith and the PC can read them without difficulty. Sigh.

We're beginning to wonder if there's anything the Eagle won't do, if you can just figure out how to do it. I mean, surely it's obvious that you use the /i option to format 40-track disks? Surely there's no need to *document* something so obvious?

Flash: I read the above to Eagle's Product Manager. The /i stands for IBM; he discovered it by accident one day when the engineers were out to lunch and he wanted to format a disk to get programs off an IBM PC. It turns out there are a number of "/" options in the Eagle. None are documented.

I like the Eagle a lot, and we are collecting notes for the revised manual; it's a great machine, but wow! does it have lousy documents. Fortunately, Eagle is working hard to remedy that. Stuart LeVine, senior scientist in the company's Advanced Technology Group recently called to say that Eagle is completely revising its technical manuals. It also has DOS 2.0, which we haven't yet tried but we're getting to now. Its documents *explain* most of the 1600's hidden features.

Pascal Speed

Gene Allen of Newport Beach, California, offers the following Pascal MT+ program:

```
Program WORK;
  VAR
    N : INTEGER;
  BEGIN (*WORK*);
    FOR N := 1 TO 100
      DO WRITELN (1.0:3:1);
  END (*WORK*)
```

He says, "When compiled and run on the Compupro machine under CP/M-80 it takes about 3 seconds to run. When compiled for PC-DOS using the new compiler from Digital Research it takes over 45 seconds!

"True, the IBM is a slower processor, but much of the speed difference comes from the fact that DR uses double-precision reals in its PC-DOS version of MT+86.

"The effect of this is that those of us who used MT+ now have programs that run in about 5 minutes under CP/M and about an hour under PC-DOS."

He concludes that Pascal MT+ is portable, but it is not usable.

I sent a copy of his letter to Digital Research and got a reply from Rick Rosenbaum, engineering manager, who says, "The program does indeed run slower when compiled under PC-DOS. However, the speed difference is not due to use of double-precision reals, as Mr. Allen states,

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Rollover/false keying	5	**5**	3	4	4
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but is due to real I/O [input/output]. In fact, if the FOR statement is replaced by

```
R: = 1.0;
FOR N:=1 TO 100 DO
  R:=R+1.0;
  WRITELN(R:3:1);
```

the program runs in less than 3 seconds. Since few people need to do repeated I/O like the example Mr. Allen gave, we believe the PC-DOS implementation of Pascal MT+ is a powerful product that allows the writing of portable programs."

Alex, who's very interested in Pascal, says they're both right—but Pascal MT+86 is notoriously slow in real I/O, much slower than it ought to be. Even with our Eagle, which is much faster than an IBM PC, we see the poor machine slow down and strain when an MT+ program causes it to write lots of numbers to the screen.

DR's Rosenbaum says, "We are committed to Pascal MT+ and will continue development work to produce faster and more powerful releases of the product."

I sure hope so. We're writing our big Inferno game in Pascal MT+ largely for the portability between PC-DOS and both 8- and 16-bit CP/M systems; despite MT+'s problems, it remains our favorite for big programs. We intend to convert the program to Modula when Modula stabilizes a bit; of course at the moment there's no Modula for CP/M 2.2 systems.

Turbo Pascal

There's a new Pascal out that we haven't had much time with, but what we have seen, we like.

Turbo Pascal, by Borland International, comes close to what I think the computer industry is headed for: well documented, standard, plenty of good features, and a reasonable price.

Well, almost reasonable.

That is: Borland advertises Turbo Pascal for $49.95, and indeed will send you the compiler and all the documents for it; but in the fine print of their license agreement it turns out you don't really own the compiler, and you cannot either sell or even give away programs compiled with it unless you buy an additional license from Borland.

My first reaction on reading this was to ignore the product. What need have we of a compiler that you're not only supposed to confine to a single machine, but whose output programs can be run only on the original machine? Both Microsoft and Digital Research tried that nonsense. Digital gave it up completely, and Microsoft mostly did. A fine product Turbo Pascal might be, but using it would be a solitary vice.

I called Borland's president, Phillipe Kahn. His story is that Turbo Pascal is the cat's whiskers, best thing to come down the pike in years, much better than Pascal MT+, which costs $600. Borland is a small company that needs money and wants to sell at a low cost, but shouldn't the company get something for its efforts? Anyway, you can use Turbo Pascal for yourself for only $49.95, but

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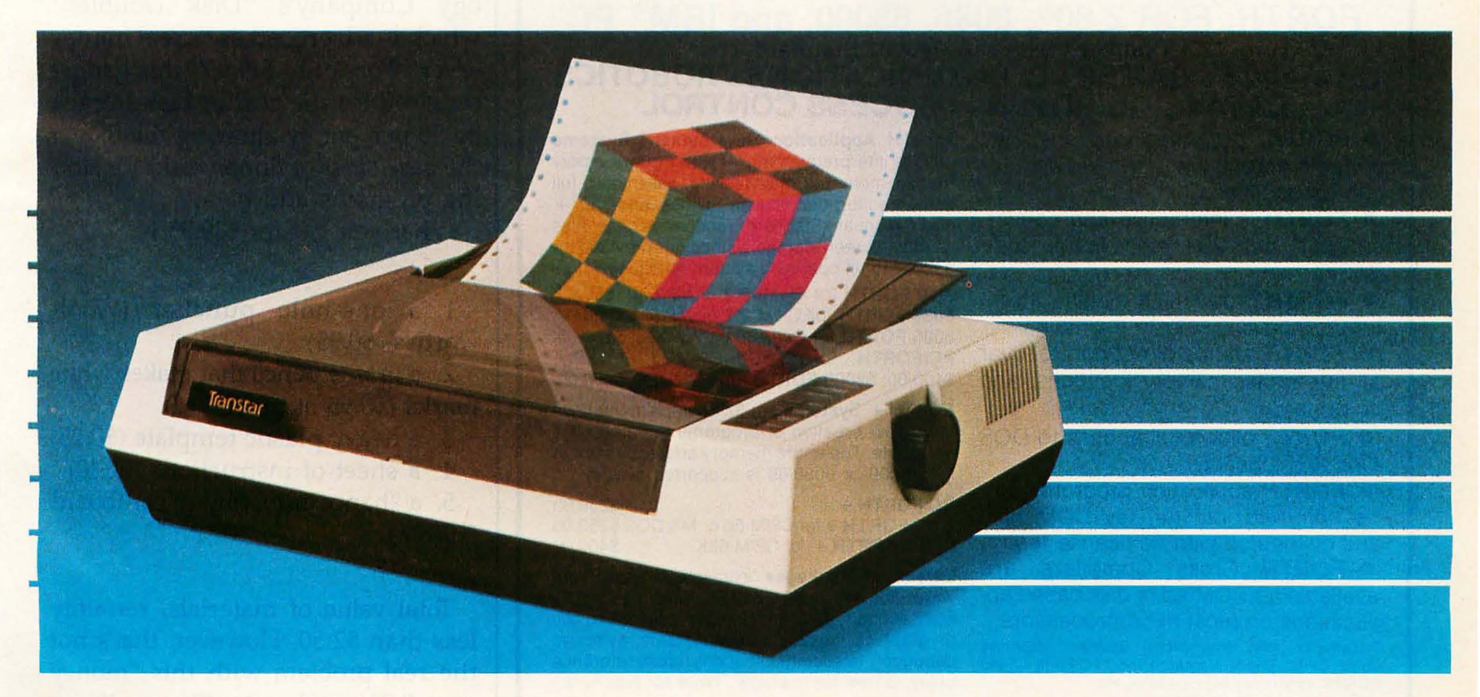
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commercial users should pay more.

"How much more?" I asked. I still wasn't much enthused.

However, it turns out not to be a lot more. Borland only wants another $100 for what amounts to an unlimited license. Thus the true price of Turbo Pascal (for those who intend to sell or give away their programs or to run programs compiled with it on any machine other than the one they bought the compiler for) is $149.95.

My first impression of Turbo is that it's probably worth $149.95. It looks to do everything MT+ *with the Speed Programming Package* does, and maybe even do it faster and better.

It comes with a built-in editor, much like the MT+ Speed Package or UCSD Pascal. There are lots of utilities. It generates native code, like Pascal MT+, not p-code like JRT Pascal and UCSD Pascal; but unlike Pascal MT+, there are trace debugger capabilities that let you find the source code that produced a run-time error.

The document is a printed book and is quite complete, much more than adequate provided that you're not trying to learn Pascal from it. The book is certainly no tutorial intro to the language—although Mr. Kahn promises a tutorial Real Soon Now. It hardly matters; at that price you don't expect a tutorial. Get Alex Pournelle's Pascal Intro and a couple of good books, and you'll still be around $100 for a good learning package (unless you intend to sell or give away your programs).

Meanwhile, I find myself impaled on a real dilemma.

First: I want to encourage outfits like Borland. I think software is priced far too high. Heck, I'd consider a good Pascal compiler for $150 to be a step in the right direction. Why, then, am I upset if Borland offers the exact same compiler for $49.95 on condition that you don't sell or give away programs developed with it?

Because it's a tax on honesty. Suppose I buy Turbo Pascal for $49.95, like it a lot, and write a good utility program with it. My friends like my program and want copies.

I now have two choices: be a liar, or pay $100. Maybe I like Turbo Pascal so much that I'll pay the $100 out of gratitude; I understand there are customers who have. On the other hand, a lot of people are going to say to hell with it, and how is Borland going to enforce its "agreement"? I doubt Borland can, and suspect it won't try.

Anyway: my original intent was to see how hard it would be for Marty Massoglia to translate our Inferno game from MT+ to Turbo Pascal, but I was scared off by the licensing agreement. Now that I know a "no strings" agreement is only another $100, I'll reconsider. I'd think that a fair test of Turbo.

Meanwhile, Phillipe Kahn of Borland promises that upcoming releases of Turbo will include source code to a bunch of useful programs including a spreadsheet. Borland intends to get into the Pascal market in a big way, and I very much like that attitude. I'd like to see the company succeed; it's about time compiler prices came down to something reasonable.

There's Value for You...

I have acquired Evolving Technology Company's "Disk Doubler," which is advertised as "a real money saver." For "only $19.95" this gadget can "reduce the cost of disk storage by 50 percent by allowing the use of the back sides of floppy disks for storing programs and data."

What you get for $19.95 is:

1. a one-hole puncher (Woolworth's, $0.95)
2. a grease pencil that makes white marks ($0.95 at most)
3. a heavy plastic template ($0.25)
4. a sheet of instructions ($0.10)
5. a "happy face" slip of cardboard ($0.005)

Total value of materials, certainly less than $2.50. However, that's not the real problem with this "money saver." The real cost will come if you use it.

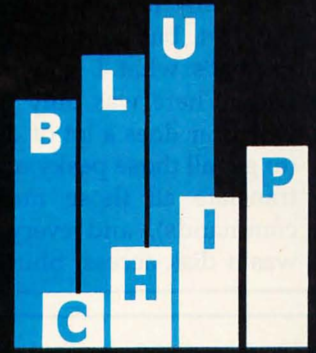
So far as I know, all floppy disks have magnetic media on both sides

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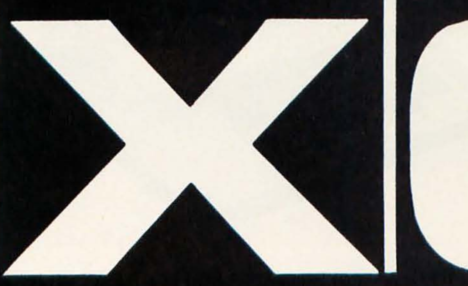
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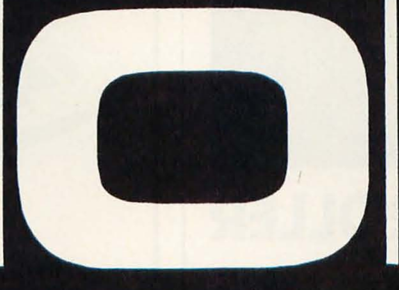
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of the disk. Many disk manufacturers test both sides of every disk. If both sides pass quality-control inspection, the disk is sold as "double-sided," and the code holes are punched in the jacket accordingly. If one side fails the tests, the disk is marketed as single-sided. If both sides fail, the disk is either scrapped, or marketed to a discount disk outfit, which puts it through less stringent tests.

Consequently, there's no guarantee at all that the "other" side of your disk is usable—or worse, that it won't fail catastrophically. By Murphy's laws, that disk will fail when it contains the only copy of something extremely valuable.

Ezekial, my late friend who happened to be a Z80 computer, had only one failure in his first couple of years. We eventually traced that failure to cheap disks: one had actually let media rub off on the disk-drive head. That crashed the drive, but not when the el cheapo disk was in it. Oh, no. It crashed when I was saving some original text. Even Tony's bulletproof software couldn't save that particular chapter. Moreover, it kept crashing, and it took some severe scrubbing with alcohol to get the gubbage off and make the drive reliable again.

Since that time, I've been pretty careful about what kind of disks go into my machines. By staying with high-quality disks like Dysan, I protect the disk heads from wear. Most important, though, I protect my data.

All in all, using the back sides of single-sided disks seems to me a good way to invite trouble. It might work, and save a few tens of dollars, but mark my words, there'll come a time when you regret it.

Crashing Shirley

One of the hits of the CP/M East show last month (October, 1983) was Bill Godbout's (of Compupro) multiuser machine. It has some kind of official name, but I first heard of it under the code name "Shirley," and that's what I remember it by.

Shirley is a business machine. It runs CP/M 8/16; that is, there are both 8-bit and 16-bit processors aboard, and you don't have to tell the system whether you want to run CP/M 2.2 or CP/M-86; Shirley's smart enough to figure it out once you invoke the program.

I'll have more about Shirley after I get mine; it's more than just possible that we'll set her up as the master writing machine here, and no, I haven't given up my notions about distributed processing and "one user, one CPU." Shirley has a separate microprocessor ("brain") chip for every user as well as a master brain to do traffic management and give all four users access to the hard disk; but back to my story.

Godbout had Shirley set up for CP/M East. It was my first chance to play with it. Godbout didn't have Write, my favorite text editor, running yet, but he did have Wordstar, so that's what I called up to play with. There was only one trouble: Wordstar does a lot of disk accesses (to get all those pesky messages and translate all those multiple-stroke commands), and every time there was a disk access, Shirley crashed.

Circle 85 on inquiry card.

Compupro tends to have loyal employees; I never will forget how the staff stayed with the booth in the 106+ degree temperature of the outside tents of last year's NCC. The overflow tent area quickly became known as The Inferno; a lot of exhibits shut down because the machines couldn't take it. I got considerable comfort from it, though, because a duplicate of my Compupro system continued to work even though I measured the input temperature at 105 degrees. The staff was wilting before the machines were.

Anyway, when I made Shirley crash for about the third time, one of Compupro's young women came running over in a state of high dudgeon, and I abandoned my fun; but it was annoying. As it happened, I was scheduled to have dinner with Dr. Godbout and his crew that night, and we got to discussing what had happened, and somewhere just after the soup it came to Len Ott, Godbout's software-development manager.

"We mixed up Wordstars," he said.

After that it was easy enough to see what happened.

Wordstar comes in both 8-bit and 16-bit versions, and Shirley can run either. Now CP/M 2.2 (8-bit) command files end with the extension .COM, while CP/M-86 (16-bit) command files end with the extension .CMD, so that's no problem. However, Wordstar has overlays, lots of them, that are called in every time you use one of the multiple-stroke commands—and the overlays have exactly the same names and the extension .OVR whether they're for the 8-bit or the 16-bit version.

Somehow in the mixup of bringing the exhibits (with new furniture not tried before), both .COM and .CMD versions of Wordstar had got onto the hard disk, with the wrong one first, so CP/M 8/16 loaded in the 8-bit command file—which promptly called the 16-bit overlays.

Needless to say, they had that particular problem fixed before I arrived at the show the next morning, and, in fact, someone was watching for me to drag me over and show me they had it working. They'd simply eliminated all the 8-bit Wordstar parts

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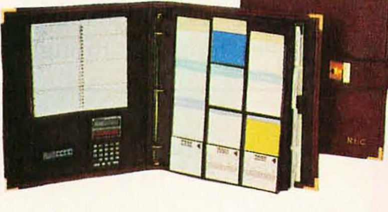


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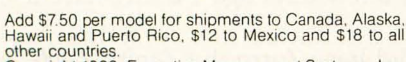
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from the system, which took care of the immediate difficulty.

The long-term solution is to patch 16-bit Wordstar so that it wants overlays with a .16V extension (or some such). Micropro doesn't tell you how to do that, although I gather that some systems consultants have the secret. Len Ott is working on the problem for Compupro; meanwhile, fair warning to anyone using CP/M 8/16. Don't mix Wordstar overlays.

Much Improved...

Another thing I collected at CP/M East was the new manuals for Wordstar 3.3.

I recall the first time I ever saw Wordstar. It was at a show in Los Angeles. MacLean, my late mad friend, and I had machines with memory-mapped video because Electric Pencil wouldn't run with a terminal; indeed, the only full-screen editor that would work with terminals was Wordmaster, and it didn't have word-wrap and other features that I wanted for creative writing.

Micropro, the company that brought out Wordmaster, introduced Wordstar. It was selling it from a small, against-the-wall booth, and the demonstrator/salesman told MacLean, "The documents were written by the programmer who wrote the program."

Wordstar will never be my favorite editor, but the company has steadily improved it, and it's certainly more than adequate.

Dan thumbed through the big notebook and said, sadly, "I can very well believe that."

We stayed with Electric Pencil, partly because Wordstar would work *only* with terminals; it certainly couldn't take advantage of our fast-scrolling memory-mapped video displays. Even if we'd been tempted, though, the first Wordstar documents would have turned us off.

However, most of the micro community wasn't willing (or perhaps able) to put in memory-mapped video systems, and Wordstar was for several years the best text editor available for systems using terminals. The result was that Wordstar very nearly became the micro world's standard text editor. It wasn't necessarily the favorite editor, but it was a pretty good second best. Everyone knew it, and it was available on most systems. It was smart to learn it, despite the poor documents.

Over the years Micropro improved Wordstar and improved the documents, and I'm pleased to report that the new documents for Wordstar 3.3 are not bad. The tutorial is still too terse and far too "busy" for my taste, but it will serve, and the reference manual is quite complete. Wordstar will never be my favorite editor (they'll never make changes that drastic!), but over the years the company has steadily improved it, and it's certainly more than adequate.

Interestingly enough, the keyboard pictured in the new Wordstar tutorial manual is very much like mine, except that it's missing most of the special function keys. Has Wordstar discovered just how good Archive keyboards are?

Love That MPI

I've become involved in publishing. That is, my friend and long-time associate Jim Baen has talked me into a line of "Jerry Pournelle Presents" books. One of the first of these will be a revised collection of these columns. Others will include books by Tony Bove and Cheryl Rhodes on how to use CP/M and word processors and such, an authoritative guide to the IBM PC, and a tutorial on Modula-2.

I'm editor of record, so I contract for these books, and that's greatly increased the paperwork here at Chaos Manor. Worse, Jim Baen has his standard contracts on his IBM PC, and until a few days ago I didn't have a PC.

I did have Zorro the Zenith Z-100, which in many ways is a better

machine, and the MPI 150G dot-matrix printer, which is faster than the letter-quality Diablo and NEC printers, and plenty good enough quality for contracts and business documents.

We set up Zorro out in the auxiliary office where the whole staff as well as the kids can get at him, and demand has picked up a lot—so much so that people were chafing to get the printing done so they could get back to work.

MPI came to the rescue. That's one great little printer. The MPI ("The Printer People") troops sent an update board for the 150G. It was simple to install, and it loads the printer with 68K bytes of memory. Now when we want to print a contract, we do just as we always did, but when Zorro has sent the entire file over to the MPI 150G, we can start editing something else while the printer continues its work.

The time saved is quite significant. It's even more significant when we're printing Write files; it seems that Wordstar takes quite a long time to go through the text files and do all the necessary formatting. The MPI printer is so fast that it can nearly keep up with Wordstar! However, for Write, program listings, and all the myriad details that one uses a printer for, having that memory is little short of wonderful.

I know there are various boxes of memory that sit between the computer and the printer, and I've always been tempted to get one, but I never have. I suppose one reason is that early on MacLean set me up with a "spooler," which is something a bit different; the spooler, or at least the one I had, is a software timesharing system that let the computer print during pauses when nothing else was happening. It almost drove me mad.

The printer was in the other room, but I could hear it. Whenever I'd pause for thought, the printer would start; as soon as I hit a key, it would stop. All pretense of creative thought went out the window, and I had that darned spooler erased from all my disks so I'd never be tempted to use it again.

That somehow convinced me I didn't want printing going on when I was working. Then, later, I got a second machine and hooked it to the printer, and that became the primary printout system, and I found I could work while the printer was going in the other room, so long as it worked steadily and didn't depend on what I was doing at the time. It's only been recently that I find I wish I had access to the second machine while it's printing; and our experience with the Z-100 and the MPI's magic memory has been so pleasant that I guess I'll start looking for a box to connect between the Compupro Dual Processor and the NEC 7710 Spinwriter.

Meanwhile, if you want a *good* dot-matrix printer, let me recommend the MPI. We also have its little brother, the MPI 99, which is destined to be attached to the IBM PC as soon as we get either a parallel-output board for the PC or the serial-interface adapter cable for the MPI 99.

The Ultimate Language?

Buz Overbeck of Garland, Texas, has evidently been following my language debate articles and has decided to solve the problem once and for all. He sent me the specifications for the new language DeSade, which he thinks should come out of the closet.

According to Overbeck, DeSade "is perfectly suited for brute-force applications, slow and dirty programming, the crunching of numbers, and hacking in general." Some of the previously defined functions are STRIP (X$), which removes everything; FLOG(X), which returns the floating-point logarithm; SLASH(X), which returns the integer portion of X; MAIM(X), which returns nothing; and SIN(X), which restores X to its original illegal value. Alas, I can't really do justice to DeSade and its library function Libertine—at least not in a family-type magazine like BYTE. Perhaps that's just as well.

That Won't Work...

No one has yet deciphered my secret message encrypted in Charlie Merrit's public-key encryption system. I know for a fact that some

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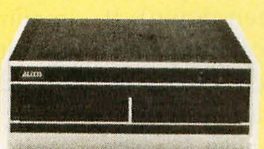
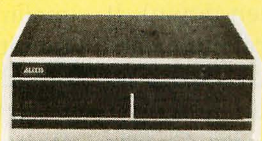
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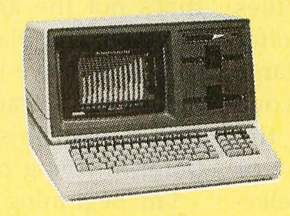
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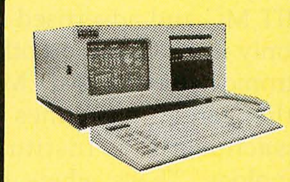
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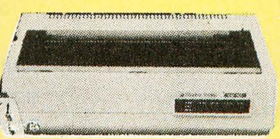
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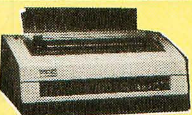
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pretty bright people using fairly large machines took a stab at it; so perhaps it's reasonable to conclude that Merrit's program works as advertised.

For those who came in late, public-key encryption systems have two keys. One is published, and anyone can use it to encode a message. However, once the message is encrypted, it can't be decoded except with the other, *secret* key. This means that you can give your friends the means to send you secret messages that only you can read.

About a year ago, I encoded my Vita (whose plain text is known) and a "secret" message I made up and published both messages and the encryption key, with the stipulation that I'd have a reward for the first person to send me the plain text of the message. I made it available in my files at MIT MC and advertised my offer not only in BYTE but on other large electronic networks. (MIT MC is one of the larger machines at the Massachusetts Institute of Technology. That's where my electronic mailbox is located.)

No one has it yet. There have been a couple of noble tries; one chap tried to disassemble Merrit's program in hopes of figuring out how Charlie did it. That didn't work, because the encryption algorithm is no secret: it involves factoring very large numbers.

Public-key encryption systems have two keys: one is published and anyone can use it, the other is secret.

Another try is from Mr. Buttery in Australia, who used psychology: he figured out that I'd simply encrypted the original offer of a reward. Alas, that's not the answer. I've actually forgotten the plain text of my message (I do have it written down). It breaks into a grammatical but meaningless English sentence; there's no point in trying psychoanalysis.

I'm beginning to believe Charlie Merrit has actually produced a nearly unbreakable code that we can use on our micro systems. That has some interesting implications.

More Mail...

Alas, another 21 pounds of mail (as weighed by UPS) arrived today; that's a week's supply. It's physically impossible for me to answer it all; I do read every bit of it (so far), and much of it is very informative; it's as if I had my own intelligence service out there. Thanks.

One of my most informative correspondents is Paul Chisholm of New Jersey. He says, "I'm writing this with Spellbinder, a.k.a. Word/125. Boy, is this thing modal! I'm used to input mode and command mode, but this 'edit' vs. command mode stuff is no fun at all."

Coincidentally, there is a furious debate going in the "Editor People" mailing list on one of the nets I frequent. It concerns "modal" versus "modeless" editors.

All the editors I use have "modes." Write, for example, has "insert" and "strikeover" modes; you toggle be-

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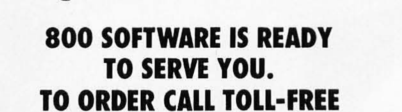
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tween them with a single keystroke. I happen to like the strikeover mode as the normal one; text editors based on MIT's Emacs tend to use the opposite philosophy. The important thing, though, is to get quickly from one to the other, and to have a way to tell which one you're in. (In most text editors there's a status line that tells you; in Write the cursor changes shape.)

Write also has a command mode, a print mode, and a find/replace mode. In every case there's a dramatic on-screen change; you're in no doubt about which "mode" you're in. On the other hand, you don't have to leave the "text" mode for most text operations, which are accomplished with single keystrokes.

Thus, although Write has "modes," it tends toward the "modeless" end of the spectrum. By contrast, consider the simple editor built into most BASICs. You pretty well have to go to command mode to accomplish anything with it. Ed, the text editor that comes free with CP/M, is another "mode" editor, as is the UCSD Pascal source editor; in those you can't even move the cursor without going into command mode.

What irritates Chisholm about Spellbinder is that he can't kill lines without changing modes. With Write that's a one keystroke command that can be made when you're in text mode. Obviously I prefer Write's method; on the other hand, I do pay for it. Many editors based on Emacs keep a big file of every bit of text you've killed and have the ability to "yank" back (unkill) that text at will. Multimode editors tend to have that feature; nonmoded editors tend not to. I don't happen to miss "unkill" or "oops" myself, but then Write won't let me kill anything larger than a line without asking me whether I'm serious.

I wouldn't reject an "unkill" or "oops" feature in an editor, but I don't think I'd pay much for it, either.

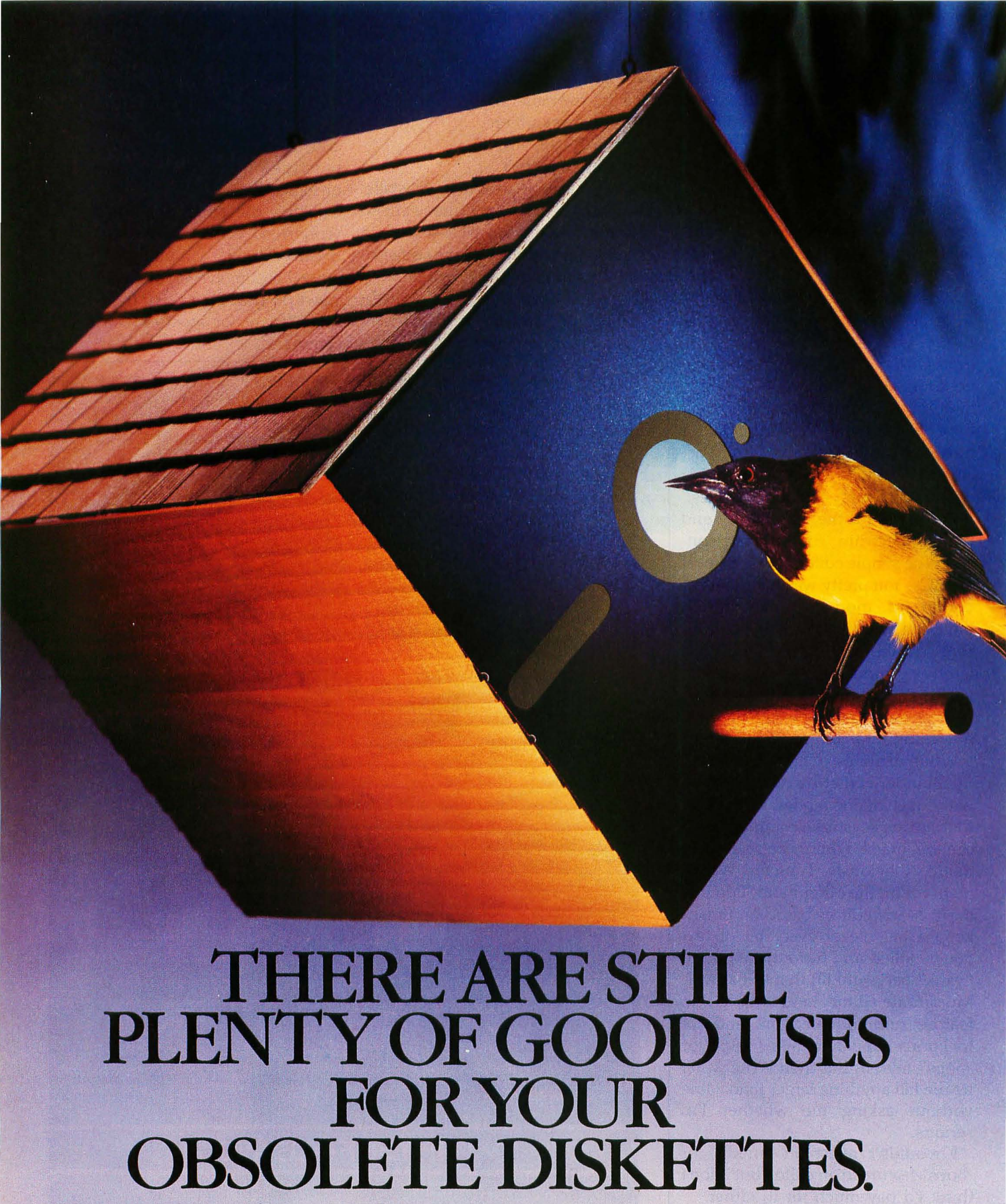
Anyway, Chisholm says, "Chalk up a 'nay' vote for Spellbinder." On the other hand, Marty Massoglia has been doing our Inferno game in Pascal using Eaglewriter, which is Spellbinder under another name, and he's not unhappy with it. But he's writing programs, not text; he also has the patience of an IBM FORTRAN programmer. . .

More on Editors

Doug Hazen Jr. lives in Gainesville, Florida, where my mother went to college many years ago. He started off asking one or two questions and ended with a nine-page letter of queries, all sensible; but I'd have to write at least one book to answer all of them.

One point he makes is that I may have been unfair to The Final Word. Why, he asks, can't I simply customize its command structure to my liking? After all, he says, "You *didn't* criticize Wordstar's commands, and it doesn't even pretend to be mnemonic or logical."

Taking the latter point first, I've written so often about Wordstar's multiple-stroke commands that I guess I assumed everyone knows my views on the subject. For the record: I don't care for most of Wordstar's command structure. The part I do


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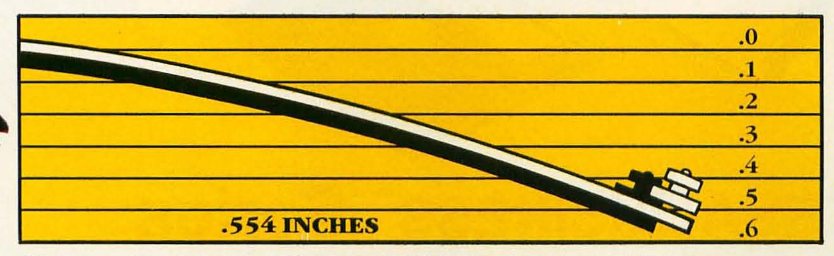
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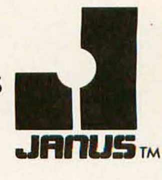
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like is the cursor controls, which are grouped in a logical manner. I find it much easier to remember that ^E, ^S, ^D, and ^X move the cursor up, right, left, down, than to remember the Emacs "philosophy" of 3^F for forward a letter and Escape-F for forward a word, etc.

Obviously, there's no universal agreement on this. The Final Word is based firmly on MIT's Emacs editor, which was written by my friend Richard M. Stallman; and a *lot* of people are not merely fond of Emacs, they're fanatic supporters. I use Emacs when I'm connected to my account at MIT, and I manage well enough. It's true that I prefer Write, on the grounds of transparency, but recall that I am a creative writer, and my requirements are much different from those of a programmer, or even of a technical writer.

Second question: "One of The Final Word's most advertised and (seemingly) important features is the ability to recover from power loss, etc., without losing text or even your place in the text. Can Write do this?"

No.

I don't think I want it to, either. The Final Word accomplishes this miracle with a "swap file"; every now and then it writes off what you've done to disk without your asking it to. It's probably pure prejudice on my part, but I find that distracting. I don't want my editor doing things I didn't tell it to.

On the other hand, I've been well trained to "save early and often," which I do. I have fast disks, and I save my text whenever I finish a unit. Still, I concede the point to The Final Word.

Hazen also asks what I think of "what you see is what you get" editors.

I couldn't care less about that feature. Write has a "print to screen" command that lets me see on screen precisely what I'd see on paper, and that's plenty enough for my purposes. On the other hand, the output of my shop is pretty much confined to (1) letters and (2) standard manuscripts that are formatted as 26 double-spaced lines per page, each 60 characters wide, with page num-

bers and a very short header. I don't need fancy formatting.

What I do like is automatic on-screen formatting. That is: Wordstar and most of the "what you see is what you get" editors insert various "invisible" formatting commands into the text stream. If later you change anything, such as the length of a word, you must consciously reformat the paragraph, otherwise it won't come out right.

For example, if you use a good spelling checker like The Word Plus, it will tell you that in making corrections it has changed the length of words and suggest that you REFORMAT your text.

Write, on the other hand, works from explicit text-formatting commands. They're quite visible because they start with a dot; for example, you set the left margin to 10 by doing .lm10 and set the header margin (space between header and top of text) by doing .hm3 or whatever. Having done that, Write does the rest. When I edit already written text, Write automatically reformats it on screen. When I run The Word Plus, I can immediately print my text without reformatting, regardless of whether words changed length. And so forth.

I prefer it this way. If I did a lot of newsletter publishing or intricate text layout, I'd probably have a different view. I do know that Write is good enough to produce important documents; the report of The Citizen's Advisory Council on National Space Policy was printed here at Chaos Manor using Write, and it got a letter of commendation from the President, so it must have looked good enough.

Actually, I expect much editor preference depends on what you're used to; as long as you have a decent text editor, these machines are so much better than what we had before we got them that we can loudly count our blessings.

Still, I am making notes about what I want in my "ideal" editor and, who knows, maybe I'll use parts of it as an example when I start writing about how to program in Modula-2.

Upgrade? That Compupro

I'm writing this on a Compupro Z80. I want that clearly understood; maybe I can forestall some of the angry letters.

Bill Godbout's Compupro company has sold one whack of a lot of Z80 microprocessor boards. It still sells them—but he's trying to retire them. What Dr. Godbout really and truly wants you to get is a dual processor, 8085/8088 central processing unit, and while you're at it, get CP/M 8/16 that runs both 8-bit CP/M-80 (2.2x) software and 16-bit CP/M-86 programs.

To encourage this, he's making two offers:

(1) If you have Compupro CP/M-86, return the original master (you can keep a copy) to a Compupro Systems Center and the company will sell you a working CP/M 8/16 complete with BIOS for $100.

(2) If you have a Compupro Z80 microprocessor, talk to your Compupro Systems Center, or even direct to Compupro; you can arrange to trade it in and get a Dual Processor 8085/8088 replacement board at half price.

Now I know that some people won't consider this an upgrade, because the Z80 does have some pretty efficient instructions not present in the 8085. Phillipe Kahn of Borland says the reason the company's Turbo Pascal is so efficient for CP/M-80 is that it works only with Z80 systems and makes maximum use of the Z80 instruction set.

On the other hand, the micro world is moving toward 16 bits. There's more 8-bit than 16-bit software right now, and the Z80 will run more of it than the 8085, so perhaps this isn't the time to make the change. Perhaps. I have both systems, and there's very little I can't run on the Dual Processor—which also has Jim Hudson's 8087 piggyback board, thus enabling me to do even more wonders.

Anyway, while Dr. Godbout and I were discussing his trade-in offer, he said he was contemplating calling Nieman-Marcus to get into its Christmas catalog. He could offer a $100,000 microcomputer.

Take one each Shirley machine. Each of the four users could have his own CPU and memory. They could also have their own RAM-disk if you'd like. You can make the RAM-disk as large as 4 megabytes and the individual memory area up to 16 megabytes. This requires the new 256K-byte memory chips, which aren't cheap.

With two floppy disks, a hard disk, 16 megabytes of main memory, 1 megabyte of RAM-disk, five processors, and terminals, you could put together a Super-Shirley to sell for $100,000, and he was going to try to get that in the Nieman-Marcus catalog.

Of course, Shirley doesn't normally sell for anything like that; with four terminals it's still well under $20,000 for a four-user system.

I don't know whether Godbout got his ad in that catalog, but he does have a point: it's going to be awhile before those 256K-byte chips make any practical difference to the ordinary microcomputer user.

Meanwhile, Godbout is developing a 1-megabyte S-100 *static* memory board that will take up only one slot. You can probably order one now; if you decide you want one, it will be about $6000, no small sum. Of course, that price will fall over the next year or so; memory prices always come down.

As to why anyone would *want* such an expensive board, it will work at fantastic speeds, far higher than where the cheaper dynamic memory boards can work reliably. I already have a Compupro 8-MHz 8086/8087 microprocessor board—and the company is trying to increase that one's speed. Moreover, with a board like that you're tooling up for the real thing, when the 16032 boards come out.

My conversation with Godbout got me to thinking. People are always asking me, "What should I buy?" Short of giving a specific machine for an answer, what should I say? But I have thought of something.

Buy yourself a state-of-the-art development system—but don't get *this year's* model. Get something that between one and one and a half years ago was the latest state of the art. That will be advanced enough for almost any nondevelopmental purpose. People will be writing software for it. The bugs will be shaken out and its servicing quirks will be known.

Example: I'm writing this on a Compupro Z80, which was state-of-the-art three years ago, and I'm about to check spelling and print it on a Compupro 8085/8088 Dual Processor, which was state-of-the-art not more than two years ago. Both are reliable, quite sophisticated, and easy to use.

Incidentally, I told Bill Godbout about a new company that's forming to challenge his supremacy in the development systems market.

He said, "Love competition. I'd like to have somebody to steal something from for a change."

Fixing up Adeline

The Otrona company has changed hands, and no one in it seems ever to have heard of me. The company has severed its connection with Fred Whitney, who used to be the local manufacturer's rep, and the West Coast sales people I knew are all gone.

Thus I hear rumors of new boards and software for the Otrona, but I've not seen any.

Meanwhile, Adeline, our Otrona, developed speech problems: that is, she worked fine, but the communications port stopped sending, making it well-nigh impossible to transfer files out of Adeline and into our main system. (There's a story that goes with that, about why my 5-inch disk systems for the big Compupro Dual Processor aren't up and running, but it's for another time.)

We also had a problem with the handle; not fatal, but annoying.

No one at Otrona returned my calls, so it took a while to find a local dealer; but eventually we came up with Omni Unlimited, of Pasadena. Alex took Adeline over. Within an hour, John Erdwell of Omni had Adeline fixed and running. Moreover, it didn't cost a cent; it seems Otrona had some problems with early machines and instructed

authorized repair centers to treat the machines as if under warranty. I don't know if the company is still doing that as you read this, but as of November it is.

We still use the Otrona as the travel machine. There's a good version of Write for Adeline, and she fits in an aircraft overhead rack quite nicely. I last took her to Austin, Texas, and got quite a lot of work done in evening hours. There are said to be better portables, but so far I've not tried one.

Late edition: Otrona has successfully reorganized. Ron Lingeman, the original designer of the machine, has become the vice-president of R&D and is happy as a clam with his return to the laboratories. The new president is Jim Linder, who enjoys sales and marketing. I met both at COMDEX. Communications have been reestablished and we are getting a PC-compatible update for Adeline Real Soon Now.

They also have a very nice large amber screen add-on. With the big screen, PC-compatibility in addition to the original Z80, and lots of bundled software, the Otrona remains my favorite portable.

Game of the Month

We've got a ton of computer games around here. My method of determining which one is most popular is to watch which ones the kids are playing when I go back to their end of the house. It's not quite a random sampling, but it's reasonable.

This month the favorite seems to be Avalon Hill's Tactical Armor Command. I'm glad of that, because I have a soft spot in my heart for AH; I've been playing its board games for at least 25 years, beginning with Tactics II.

The following review is by Alex Pournelle, with assistance from Richard (13) and Phillip (15):

Tactical Armor Command (Apple version tested; no joystick used).

"Dad used to design board war games. I got interested in them because of him, but I have had little spare time and few opponents for a long time. Because of this, I hoped to see some good *board*-type games for computers, especially from a company whose games I have admired, Avalon Hill.

"They have done it. Tactical Armor Command, or TAC for short, is definitely an Avalon Hill game right from its rules through its playability. It even has the old Avalon Hill rule gaps—for instance, the game says "fire suppressed," though the rule book doesn't mention what that is. No matter; Avalon Hill gamers would be suspicious of anything perfect in its first release.

"There is one perfect thing: the marriage of computer and board game. The last two board games I used to play were Tobruk (AH) and Air War (SPI). Both dealt with individual units, tanks in Tobruk and jet fighters in Air War. Both were *incredibly* hard to learn and play. Air War had 100 pages of rules, tables, examples, and notes; it took a friend of mine two weeks just to learn to fly straight and level! The computer can take care of this detail much better than you or I; TAC does this for a very Tobruk-like game.

"You choose American, German, Russian, or British armor and troops in World War II. Your opponent, who can be the computer or another sapient being, chooses one of the others. You select how many "armor points" (which buy tanks, artillery, or troops and APCs) each side gets and then purchase your instruments of destruction. Then you each take turns moving on the board, attempting to find each other's units, hiding in forests, laying smoke, and firing either directly or indirectly. Though the moves are entered one after the other, all moves are processed simultaneously, making the game more realistic. Combat resolution, if any, is shown after all moves are entered. All views of the playing field are shown in top view, just like any other tank board game. The hexagon paper, though, is gone: units can be anywhere.

"Good points: the game is fun and refreshingly different. If your coordination isn't up to 4000 aliens a minute, try a little strategy. You can give more units to a lesser player or play the computer if you're alone. The computer, by the way, is a pretty good player—the game calls him "Major Al Logarithm." There is no time limit during planning stages, so plan on. Moving units *is* time-dependent and you *can* make mistakes, but this is so much more like reality that I am only impressed. I could wish for optional joystick unit movement if I were in a wishing mood.

"Disadvantages: like any other Avalon Hill game, there are some endearing foibles as well as just dumb mistakes. There are not enough examples in the instructions, especially of indirect fire, messages given during combat, how to engage the enemy, what infantry is good for (and how to use it), what artillery can do for you, and what to do with every tank against every other. Avalon Hill provides good examples for its $12 to $20 box games; it certainly ought to for a more expensive computer game. You get to pick the units for both sides if you play the computer; I would like to see it do its own choosing. You have to write down what units you're tracking and where they are; the computer could do a lot more note-taking for you. If you try to point a gun in a direction it won't go, the computer just asks you again; there ought to be help on this. Most of these are minor nits, though: the game is very playable and takes only two or three test plays to pick up. I would like to see Avalon Hill add more scenarios and variable terrain so Tactical Armor Command doesn't become a bookshelf queen."

(Note by JEP: the biggest disappointment to me was that although the Germans can have towed artillery, the most famous antitank weapon of the war, the Flak 88, isn't in the game! Rommel changed armored tactics forever by bringing the 88's forward to fight as integral units with his tank armies; it would be interesting to see how that tactic fares in this game. I wish they'd add the 88s. . . .)

Coming Attractions

I'm never very good at predicting what I'll be doing, but next month is COMDEX. Meanwhile, I've been

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Dedicate/32 $175
Merrit Software
POB 1504
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Disk Doubler $19.95
Evolving Technology Corporation
3725 Talbot St., Suite F
San Diego, CA 92106
(619) 224-3788

Eagle 1600 Series $4495–8995
Eagle Multiuser PC $1995–4495
Spirit Portable $4795
Eagle Computer Corporation
983 University Ave., Building C
Los Gatos, CA 95030
(408) 395-5005

Final Word $300
Mark of the Unicorn
222 Third St.
Cambridge, MA 02142
(617) 576-2760

IBM PCs and Other Computers
Computerland of Woodland Hills
28012 Ventura Blvd.
Woodland Hills, CA 91367
(818) 716-7714

Logimouse $203
Logitech Inc.
165 University Ave., #105
Palo Alto, CA 94301
(415) 326-3885

Magic Keyboard $32.50
Write $239
Dedicate/32 $175
Workman and Associates
112 Marion Ave.
Pasadena, CA 91106
(818) 796-4401

MPI 99 $599
MPI 150G $995–1345
Micro Peripherals Inc.
4426 South Century Dr.
Salt Lake City, UT 84107
(801) 263-3081

Otrona Attaché $2995
Otrona Corporation
4755 Walnut St.
Boulder, CO 80301
(303) 940-3445

Pascal MT+80 $350
MT+86 $600
Digital Research, Inc.
POB 579
Pacific Grove, CA 93950
(800) 227-1617

Shirley (Multipro MP-10) (hard drive 40-megabyte) $8490
Compupro Upgrades —
Compupro
3339 Arden Rd.
Hayward, CA 94545
(415) 786-0909

Spellbinder (alias Word/125) $495
Lexisoft
706 5th St.
Davis, CA 95616
(916) 758-3630

Tactical Armor Command $40
Avalon Hill Game Corporation
4517 Harford Rd.
Baltimore, MD 21214
(301) 254-5300

Turbo Pascal $49.95
Borland International
4807 Scotts Valley Dr.
Scotts Valley, CA 95066
(800) 227-2400

Wordstar $495
Micropro International
33 San Pablo Ave.
San Rafael, CA 94903
(415) 499-1200

Zenith Z-100 Computer $2899
Zenith Data Systems
1000 Milwaukee Ave.
Glenview, IL 60025
(312) 391-8865

promised the new Eagle Spirit portable (which I'll take to COMDEX) and a number of expansion boards for our IBM PC, including, I hope, Ciarcia's Quicksilver.

Also on deck is Sweet Pea's plotter, Mouse Systems' Mouse compared to Logitech's, Lotus 1-2-3, concurrent CP/M with Logitech, DR Logo, and Lord knows what else.

There are also 21 pounds of mail to deal with, and the unreviewed software pile continues to grow. I love it.■

Jerry Pournelle is a former aerospace engineer and current science-fiction writer who loves to play with computers.

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE Publications, POB 372, Hancock, NH 03449. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.

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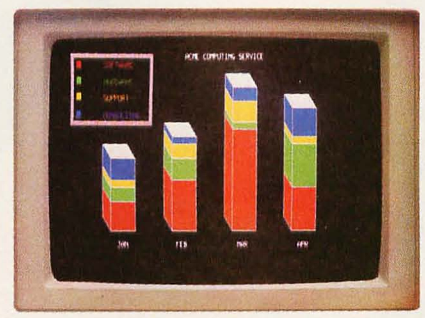
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Popular Computing
October, 1983

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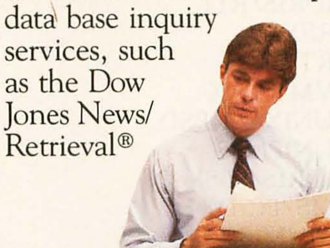


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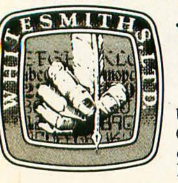
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A Business Computer, A Business Program, and More on Voice Recognition

Recent developments raise some questions about perceived industry trends

by Ezra Shapiro

North Star Dimension

The announcement this fall, shortly before COMDEX, of the multiuser IBM-compatible North Star Dimension in many ways validates what industry observers have been preaching as the formula for survival in a world increasingly dominated by the IBM Personal Computer (PC) and its imitators. The North Star Dimension is not to be confused with the Dimension 68000 from Micro Craft Corporation, a single-user system that claims compatibility with just about anything via coprocessor boards. The new machine is a best-level PC work-alike (in other words, it comes as close to being fully compatible as anything to date) that was designed to appeal to a *very* specific segment of the microcomputer marketplace.

The Dimension is a carefully planned business system consisting of a central processing unit, a 13-slot PC-compatible bus, and up to 12 satellite workstations.

The central processing unit is based around the Intel 80186 microprocessor and 256K bytes of RAM (random-access read/write memory) expandable to 512K bytes. In its basic configuration, storage is provided by one 360K-byte floppy-disk drive that can read all IBM 5¼-inch formats and a 15-megabyte hard disk, although the system will support the floppy-disk drive, two 30-megabyte hard-disk drives, and a 45-megabyte tape backup unit. Output is through a Centronics parallel port, an RS-232C serial port, and a second serial port programmable for a variety of protocols, including asynchronous and bisynchronous communication with mainframes.

Each workstation terminal is attached to a card that holds an 8088-2 running at 7 MHz and 128K bytes of RAM. Expansion boards of either 128K or 384K bytes of RAM are optional. Workstation cards or, theoretically, any other PC XT expansion cards, slip into the PC bus with no hard-wiring. Terminals feature one serial port for a local printer (or a mouse), a detachable keyboard, and a 12-inch green-phosphor tilt-screen monitor with 640- by 200-pixel IBM-compatible graphics and a 640- by 400-pixel high-resolution graphics mode. North Star currently has no plans to implement color, deeming it unnecessary in the business environment at which the Dimension is aimed.

In short, each workstation is essentially an independent computer with no permanent storage. The main board serves only as a memory manager, handling requests for programs or data from workstations on a first-in, first-out basis. The 80186 is programmed to use its RAM as a memory cache system, avoiding disk access whenever possible. This design is inherently both faster and safer than linking a group pf PC XTs in a local area network because the main board, the workstation boards, and all permanent storage media are located within the same box, and data transfer occurs as quickly as it would in any single-user computer of similar size, with little chance of signal degradation.

At the time this column was written, North Star was still *working out* preproduction details but was planning to ship beta-test systems in December of 1983 and move to full production early in the first quarter of 1984. Management seemed confident that there would be a large enough supply of 80186s available to meet their schedule.

However, while the Dimension is certainly impressive in its own right, it is perhaps even more significant as an indication of the current state of industry thinking. North Star has been around since 1976 (when it was

known as Kentucky Fried Computers) and is certainly no Johnny-come-lately in the microcomputer rat race. The company was a pioneer in S-100 system design and has been noted for the stubbornness with which it has clung to hard-sectored 5¼-inch floppy-disk drives since it began using them years ago. Although North Star has been marketing 16-bit coprocessor upgrades for its Advantage and Horizon computers for well over a year now, it has done so with little of the media fanfare normally associated with major product introductions.

Thus, it's worth taking notice when Dr. Charles Grant, one of the founders of the company, states flatly that the IBM PC has become a "standard" and that the company intends to "ride the wave" of IBM popularity to a financially secure future. When asked why it had taken them so long to embrace this new standard wholeheartedly, Grant commented that North Star had wanted "to do it right."

North Star's sales goals for the Dimension seem modest enough; the company is shooting for 2 to 3 percent of the IBM-compatible market and the same share of the overall multiuser market. Unlike earlier North Star products, which were moderate- to high-priced machines, the Dimension is certainly priced to compete. The suggested list for the basic configuration (256K-byte RAM, floppy-disk drive, 15-megabyte hard disk, and two workstations with 128K bytes of RAM) is only $7000. Upgrading the hard disk to 30 megabytes costs an additional $1000, and extra workstations go for $1500 each. Add-on RAM boards range from $300 for 128K bytes to $700 for 384K bytes. The company's advertising materials highlight graphs that compare system costs to networked PC XTs (North Star claims a 50 percent savings per user in a five-user system), and representatives of the firm tick off the less obvious advantages: multiuser software licenses as opposed to multiple purchases of the same products; no need for either networking hardware or software; and so on. North Star is developing an aggressive marketing campaign to sell the Dimension to Fortune 1000 companies. Gone are the days when a computer manufacturer could support itself with a product for scientists and hackers. With the Dimension, North Star is attempting to occupy a niche in the market that, so far, has been vacant.

One is forced to wonder which came first, the computer or the strategy. It's becoming painfully obvious that the key to survival as a major manufacturer is acceptance by the business community. The IBM PC has unquestionably opened the door to that market wider than any personal computer before it, but in so doing has made compatibility a primary factor in microcomputer design, for better or for worse. Recent announcements by North Star, Televideo, and a host of smaller firms seem to indicate that the 8088/MS-DOS/IBM-compatible bandwagon is becoming something much more like a speeding freight train.

Most thick manuals are an insult to user intelligence.

The Integrated Microman

The requirements of the corporate world have become a driving force in software design as well, and a great deal of effort has been devoted to devising software schemes that will help to shoehorn the computer into the executive office. The ideal seems to be a program that eliminates most—if not all—of the need for paper, writing implements, and filing cabinets and is (of course) laughably easy to learn. Whether such a program is practical or even useful (there has yet to be a reasonable analysis of the amount of creative thinking that goes on during the act of shuffling papers, for example) is the great moot question, but the new products continue to multiply. In the attempt to produce a computer environment analogous to an executive desktop and thereby shorten the amount of time it takes for a novice user to develop a "feel" for computer operations, more and more programs are appearing that make use of multiple windows, alternative pointing devices such as mice, graphic metaphors, and endless layers of menus.

But is all this really necessary? Much of what goes on in most offices is not particularly well organized or logical. Computers and computer programs are by their nature dependent on structures and priorities. If we assume for a moment that it will be necessary for a new user to accept a certain level of organization in order to make use of a computer, why not make computer operations a bit easier to grasp, instead of trying to replace them with an artificial desktop?

That's roughly the philosophy behind an integrated software package, code-named "Microman," from Noumenon Corporation, which will be introduced this spring at Softcon. It's difficult to describe—largely because the most accurate phrases have already been commandeered by copywriters flogging all sorts of programs, from the truly integrated packages all the way down to those that share similar commands but no common data structures.

Microman uses no icons, no mouse (although a pointing device could be added as a substitute for the cursor keys), no windows, and very few screens that could be considered menus. But it is, in fact, an extremely tightly-knit *environment* with word-processing, calculator, spreadsheet, database, business graphics, and time-management capabilities. It's one program, not a linked collection of programs that can swap data files. Microman is designed to act as its own operating system, although it allows for the transfer of files to and from the operating system supplied with the computer.

A large part of the program's power comes from its strongly hierarchical file structure. The first thing you see is a directory, which can either be the titles of subdirectories or the names of working files. You choose a file (or move down the tree to another directory) with the up and down cursor keys. If you wish to create a new file,

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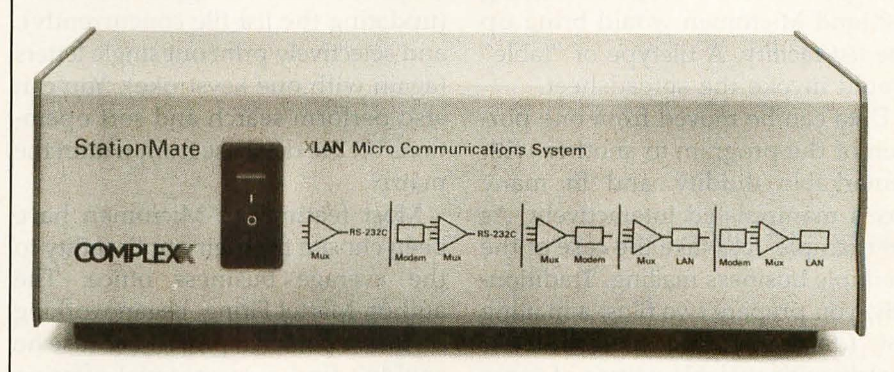
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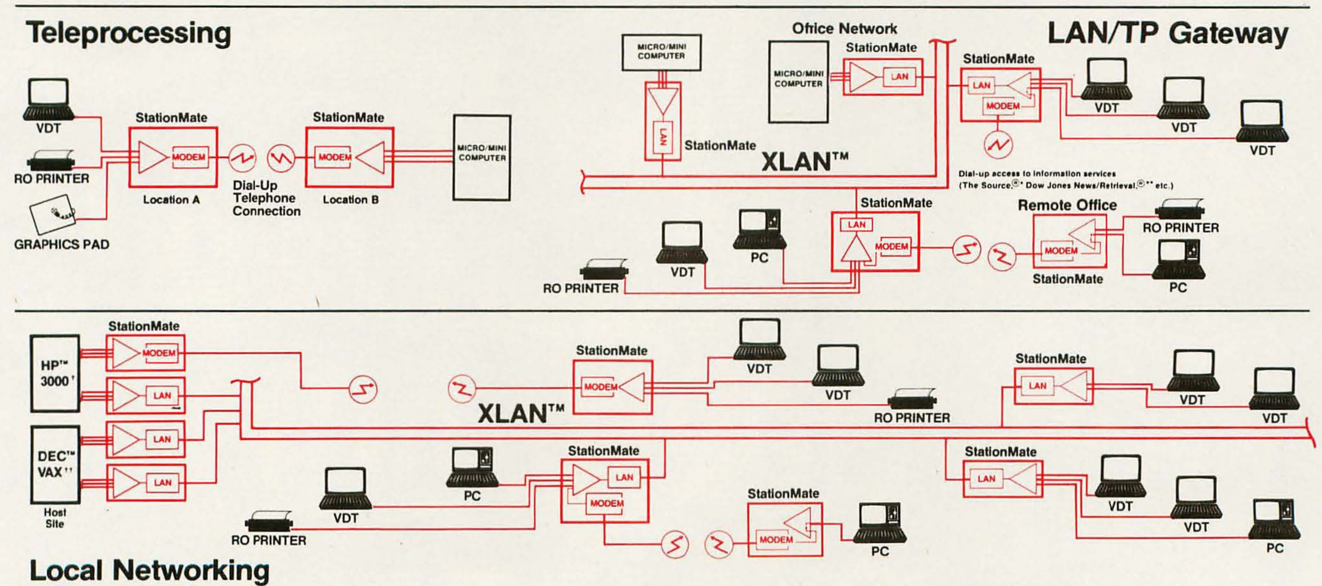
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you merely move the cursor to the beginning of a line and begin typing.

Because Microman is self-contained, there is no need to use CP/M or MS-DOS file-naming conventions. Microman allows you to name files with descriptive phrases of up to 67 characters, and blanks and punctuation marks are perfectly acceptable. The loose equivalent of a filetype specifies not only the nature of the information contained in the file but the part of the program used to manipulate it. For example, a file named "Potential Clients" with the filetype "record" would be a mailing list, and Microman would bring up the list facility. A filetype of "table" would invoke the spreadsheet.

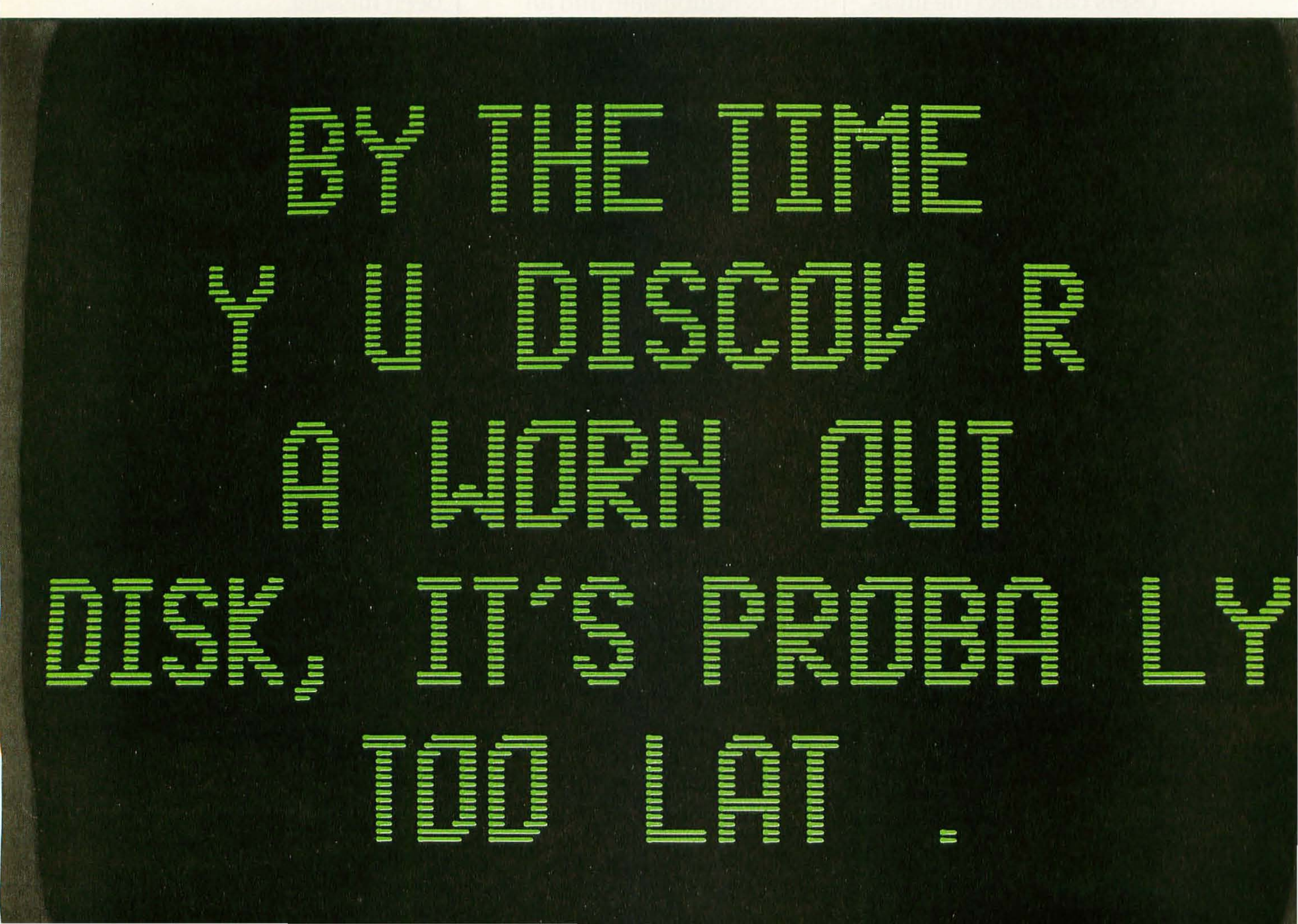
Data can be moved from one portion of the program to another with remarkable fluidity, and in many cases manipulated interactively. As an example, let's take the case of the multiple business mailing. Traditionally, you prepare two files, a mailing list (database) and a form-letter matrix with variable names of some sort to indicate where the database items should fall. These files are independent and are brought together at output when the program inserts list items into the appropriate holes and adjusts the copy accordingly.

With Microman, the letter and the list are prepared as separate files. You can tag the two files (with one keystroke each) at the directory level and proceed to output the merged form letters as previously discussed. However, if you wish, you can tag the files, enter the matrix file, view the list items one at a time in position in the letter, make changes to the items (updating the list file concurrently), and selectively print out single letters (again with one keystroke). You can also perform search and sort operations on the database from within the matrix.

Most features of Microman have been chosen for their applicability to the average business office. The author, Martel Firing, began working on it as a personal project because he couldn't find a commercial offering that suited his needs. Noumenon does not claim that Microman has the best or most powerful features. The aim was a program that could perform most of the tasks an executive or secretary would require to conduct day-to-day affairs.

The word processor is a two-part operation, a text editor and a print-time formatter, but it is entirely adequate for the generation of memos, correspondence, and clean business reports. A calculator strip (yes, a "window," if you must) can be brought up for quick numerical computations and as quickly banished from the screen.

The spreadsheet is powerful and efficient and is designed to let you enter formulas for cells, rows, columns, or areas in simple English-based syntax. Procedures for recomputation or individual formulas can be named, so that instead of typing "Multiply gross sales × 5 % = Advertising allowance" you can enter "DO: Ad budget." Multiple procedures can be nested. Notes and free-form messages can be entered at any time without having to associate text



with standard spreadsheet units (e.g., cells).

Database entries can be made through either user-created input or output forms (which are all the same to the program), and file organization can be changed at will with no chance of damage to the data. Microman also offers the executive a time-oriented database system for the chronological entry and sorting of data—daily expenses, for example. All Microman databases are fully interactive with their report forms, as in the mailing list example just given. Databases are not in themselves computational (numerical data can be shifted to a spreadsheet table smoothly enough), but again, Noumenon sees Microman as a multipurpose office aid, not as a complex data-retrieval system.

Great care has been taken to make the program as simple to run as Noumenon feels is appropriate; function keys perform equivalent tasks in all application areas, and on-screen Help messages are available at all times. Both Firing and Noumenon president Mike Mead regard the thick manuals that accompany most computer products as an insult to the intelligence of the user and a luxury for which most executives simply do not have the time. Microman documentation is a succinctly worded booklet of under 30 pages, and significant passages are either reproduced directly or enhanced as explanation screens.

Both Noumenon officials note that the computer market has entered a new phase. In their eyes, the technically sophisticated hobbyist of five years ago and the adept enthusiast of last year will make up at most 20 percent of the eventual market; the remaining 80 percent will be composed of naive business users with neither the inclination nor the interest to use computers as much more than tools and shortcuts. Microman is targeted at that group. Mead and Firing see Microman as a program that can remain on line in all but the most specific office situations, and they plan additional program modules (in areas like communications) to further broaden its usefulness.

A brief product description such as this does not do Microman justice; explanations are often more confusing than the actual operations. But Microman accomplishes what it claims; it's "easy to use," "ready to run," and "user friendly" without being either cumbersome or overly simplistic. Microman is obviously a neatly tailored program for the intelligent, but busy, adult.

Which brings us back to the question of the "bells and whistles" the industry is hurriedly developing. If Microman can achieve its goals using only a moderate amount of video highlighting, a few well-placed rules, clearly defined function keys, and a few simple, largely self-explanatory screens, why are we getting caught up in the notion that in order to make the user interface of a program simpler and less hostile we must make the program itself even more complex? Perhaps the problem lies less in the nature of software than in the nature of software design. It's worth considering.



Voice-Recognition Status Report

A recent conference in Santa Barbara provided both mildly encouraging and mildly discouraging news on the state of the art in voice recognition. The problem of translating human speech into acceptable input for data processing is one of the stickiest the computer industry is facing, as discussed in "Speech Recognition: An Idea Whose Time Is Coming," by George M. White, January 1984 BYTE, page 213. The conference, called "Towards Robustness in Speech Recognition," brought together most of the country's top researchers in the field. No revolutionary breakthroughs were announced, but it was obvious that progress is being made, and a majority of the participants were enthusiastic about the future. As with all such gatherings, discussions in corridors and between sessions, the exchanging of ideas and contacts, were probably the most productive moments of the three-day affair.

However, brief intimations of gloom managed to creep into the proceedings every now and then. Wayne Lea, conference chairman, managed to cast the first stone in his opening address. "Speech recognizers," he charged, "are *not* robust." And indeed the cheerfulness of the mood of the conference could be phrased as "They've written off voice recognition as a dead issue, but, see, this event proves we're alive and well after all."

Speech recognizers of one form or another have been under development for over twenty years. They're of particular importance to the military (for obvious reasons—freeing an extra pair of hands in an emergency can be critically important), so research and development have been rather intensive. But the vast amount of information to be processed by even a simple speech recognizer has put a limit on expectations. However, as the ability of computers to crunch larger volumes of data at higher speeds increases, there is every reason to believe that speech-recognition technology will benefit.

Refinements of technique were reported at all levels. Advances in acoustics, microphone design, and

digital encoding have made the initial identification of speech easier; spectral analysis of input is achieving smaller and smaller error rates in matching input against stored speech patterns, or templates; and the application of probability theory for detecting meaningful words among the random noise of human speech (there are over 11,000 discrete syllables in the English language to be sorted through) is also improving recognizer performance.

But the steps forward have been incremental; even the best recognizers available today ("trained" by one speaker repeating a small set of input phrases over and over) are less accurate than keyboard data entry, although the gap is dwindling. The ultimate goal, a speaker-independent recognizer, capable of understanding a large vocabulary of nonstop human speech, is a long way off. Dick Eason, president of Voice Control Systems, one of the sponsors of the conference, makes the point by asking, "What do you do about 'Jeet?' [the contraction of 'Did you eat?']?"

In his keynote speech, Dennis Klatt of MIT, observing what he sees as diminishing returns from all the research, wondered aloud if it might be time for the industry to begin exploring new directions. Unfortunately, none of the other speakers addressed the question that was foremost in the minds of many in the audience: what about the correlation between speech recognition and artificial intelligence? It may be that in order to perfect a truly robust recognizer, we may have to recapitulate the whole process by which a baby learns to make, and use, the collection of sounds we call language.

The outlook? Commercial speech recognizers, initially speaker-dependent and with limited vocabularies, will become better, cheaper, and more commonplace for simple voice control and data entry. Over the long haul, developments may not happen as quickly as we would like to envision. ■

Ezra Shapiro is a technical editor at BYTE's West Coast bureau. He can be reached at McGraw-Hill, 425 Battery St., San Francisco, CA 94111.

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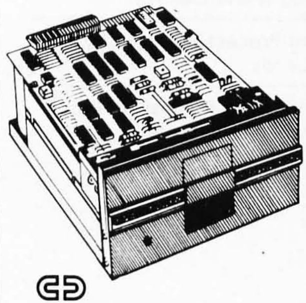
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Benchmarks and Performance Evaluation

The art of benchmarking computer languages, programs, and systems by timing them with a standard test is a popular, but inexact, science. You find only what you are looking for—speed—and nothing more. Running a benchmark program will measure the speed of the system you are testing, but how do you measure how easy an application is to learn and use, how consistent its commands are, and how well-integrated the new integrated software packages are? This month's theme articles attempt to answer some of these questions by looking at the limitations of benchmarks and considering what can replace them.

The new levels of sophistication in software and hardware are difficult to evaluate. The simple benchmarks of the past, such as the Sieve of Eratosthenes popularized in BYTE, the Whetstone benchmark for FORTRAN, and millions of instructions per second (MIPS) ratings, no longer offer relevant information about the new generation of computers.

Speed and reliability alone are not the determining factors in the decision to purchase a particular computer or application. How quickly it can be learned and put to use effectively are vital factors in the new era of mass-market consumer computers, although these factors can be difficult to test. The quality of a system must be considered as well. Evaluating computer systems as a whole is a new alternative to the traditional practice of measuring a system's speed.

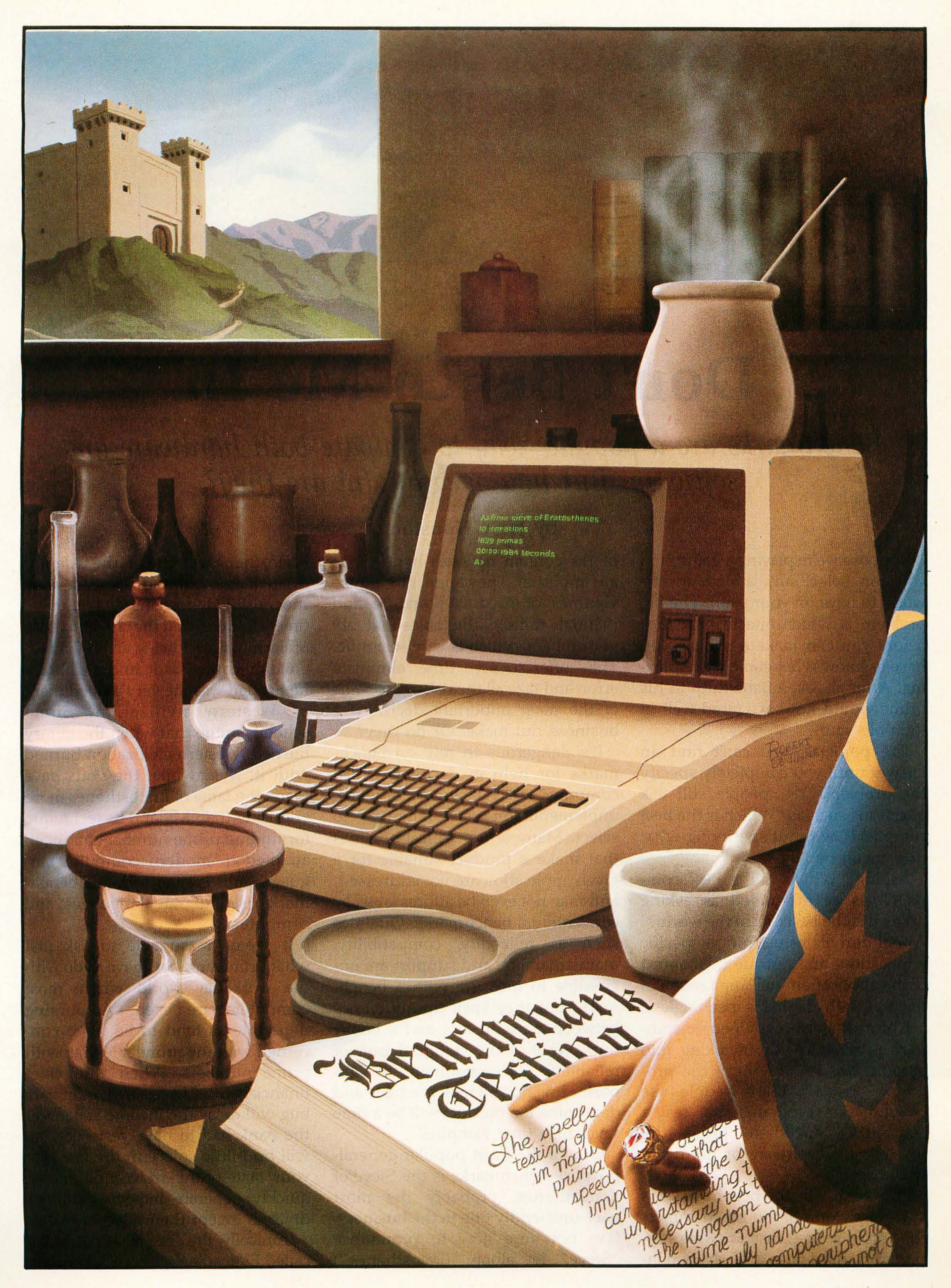
Jerry Houston of Gifford Computer Systems offers a humorous and informative look at the uses and abuses of benchmarks from a user's perspective and explains why the winners of benchmark tests are not necessarily the systems of choice. Jack Carroll and Mary Beth Rosson of IBM take another look at speed versus usability, arguing for quality in computer interfaces and suggesting tests for system quality.

Performance evaluation is becoming a popular term (especially in the minicomputer/mainframe world) for analyzing or simulating the performance of hardware and/or software. Brian Boyle of Gnostic Concepts presents the variables necessary for an equation to evaluate software performance.

Sergio Mello-Grand offers an exhaustive set of printer benchmarks to help you find out how fast your printer really is. Avram Tetewsky of Draper Laboratories discusses some of the tests to validate that software works correctly and reveals the results of some extensive benchmarks for FORTRAN compilers. Peter Marvit of Yates Ventures and Mohandas Nair of Intel come clean in the confessions of the misuses of benchmarks.

Finally, Andrea Lewis guides you through the standard features and options available on the 1984 model word processors, while Arthur Naiman provides a 100-point checklist for evaluating word-processing programs from his book, *Word Processing Buyer's Guide.* —*Bruce Roberts*

Illustration by Robert Tinney


sieve of Eratosthenes
10 iterations
1899 primes
seconds
A>
Benchmark
Testing
The spells

Don't Bench Me In

Benchmarks are a popular way to compare both hardware and software. But how meaningful are they?

by Jerry Houston

Suppose we're playing a game, and you can select any athlete in the world to have on your team. The big problem is which one to pick. But before you can make a choice, you have to know what game we're playing. After all, even Babe Ruth in his prime would not have fared well in the pole vault.

The point is, you can't find an answer until you completely specify the problem. Yet, people still ask questions such as "Which is the best compiler?" without specifying what they mean by "best."

Asking "Which is the best compiler?" is as misguided as asking "Which is the best tool in the world?" A tool derives value from a specific application, and outside the context of the application, the comparison of one tool with another is meaningless.

Unfortunately, many people compare programs without taking into account the application of the programs. Instead, these people use benchmarks—programs that test a computer's speed—to judge the worth of the software or hardware under question.

The great lure of benchmarks is that, in a world of too much choice, they promise fast, easy answers supported by hard facts. Clearly, benchmarks contain no sales hype. They are impartial. They appear to reduce volumes of product literature and manuals to tidy little tables that talk in numbers, which is very scientific. They offer to save time, eliminate error, and take all the risk out of some of the most important decisions a business can make. Or do they?

It's dangerous to rely on benchmarks for help in deciding which computer, which language, or which implementation of a language to select. Many of the critical qualities that make a product suitable for a given application are not addressed, and may not even be addressable, by conventional benchmarks. Qualities such as reliability, compatibility, maintainability, and support are impossible to measure with a benchmark, but they spell the difference between a useful tool and a booby trap. What is the standard unit of reliability, of compatibility, of support? How do you look at a table and determine if a product will be a time saver or a time vampire?

One of the most popular general-purpose benchmarks is the Sieve of Eratosthenes, probably the most user-unfriendly title in the business. (I'm not sure how to pronounce "Sieve," let alone "Eratosthenes.") Eratosthenes, head of the Alexandrian library around 200 B.C., was the most wide-ranging scholar of his time. He calculated the circumference of Earth without using an 8087 mathematical coprocessor, and the library he headed was the very embodiment of Western civilization. Some scholars argue that when the library burned, Western civilization burned with it. Meanwhile, the gods have made the fame of Eratosthenes more enduring than Mylar. His technique for finding prime numbers has been adapted to modern computer languages and is now a classic benchmark used to rate languages and computers.

It seems reasonable to ask just what prime numbers have to do with the workaday world where most computers are used. Accounting departments tend to be more concerned with the prime rate than with prime numbers. When your chief financial officer learns that a software bug will delay the income statement the bank had to have yesterday, he will find little solace in the fact that your state-of-the-art computer can quickly generate integers with no divisors except themselves and 1.

Ironically, the specialists of his day called Eratosthenes "Beta," or second

rate, for his alleged superficiality. In the computer trade, "Beta" has come to mean "not thoroughly tested," as in "a Beta copy of a new C compiler." It would be appropriate if "not thoroughly tested" were stamped on hardware and software that has been subjected to the benchmark named after our Greek who lived 2200 years ago.

A Case Study

The dubious utility of general-purpose benchmarks was brought home to our company after we conducted an extensive series of benchmarks on seven C-language compilers compatible with CP/M-86 (see "Comparing C Compilers for CP/M-86," August 1983 BYTE, page 82). After it took us almost as much time to measure performance as it would have taken us to write our own C compiler, we were struck by some curious phenomena. The apparent loser in our time and efficiency benchmarks, Computer Innovations' C86, was the compiler that our staff programmers regularly used both before and six months after we conducted the tests.

I am not a programmer; I'm a civilian. My job is to whine. So when I complained to our programmers that they should think about hopping on the world the next time it came around, they all explained that they had each tried the other compilers and found lots of good and bad points. But they felt that for the tasks they were handling, Computer Innovations' compiler was best. The reason they cited most frequently was something that became evident while we were conducting the benchmarks but that was not reflected in the tabular results. Computer Innovations' C86 was the only compiler we tested that ran every benchmark we tried and gave the expected results, and we were lifting routines from articles, books, Unix libraries, and anywhere else we could find them.

Our staff had chosen to use a compiler whose main benefits were compatibility and reliability. It ran routines taken from a variety of other implementations of C. And it ran them the first time. These features, not evident from the benchmark results, were revealed only by long experience with the compiler itself.

My faith in general-purpose benchmarks was undermined further when I learned that the Mark DeSmet compiler, which appeared to have done quite well in the benchmarks, was considered by our staff to be a lightweight C compiler. A simple case of being misled by a benchmark? Not quite. It turned out that our staff had nevertheless been taking advantage of a powerful feature of the DeSmet compiler (an advantage which, of course, was not brought out by the benchmarks) and had turned a lightweight C compiler into a novel and extremely productive programming tool. I call it the anticompiler.

Data such as "number of times per week documentation is thrown against wall" might be useful in evaluating a product.

Because our programmers primarily do system-level work, as opposed to applications programming, speed is very important. Speed to us means assembly language. The DeSmet C compiler, it turns out, lets you mix assembly code with C code. This means that, in the middle of a C program, you can insert #ASM and start writing in assembly language. This feature has streamlined the way we write assembly code.

Before we had the DeSmet compiler, we attacked a major assembly project head-on. We planned a structure, wrote the program, and resigned ourselves to debugging a maze of assembly code. The DeSmet compiler enables us to write a program initially in C. This process is fast. The program runs relatively slowly, but we can make sure that it does everything we want. Once the C version of the program works, we convert one C subroutine into in-line assembly code, compile the new hybrid C-and-assembly version, debug it if necessary, and proceed to convert the next C subroutine into in-line assembly language. Eventually, the entire program is converted to assembly language, piece by piece, producing code that is well structured, well tested, and usually well ahead of schedule. The benchmarks give no indication of this capability of the DeSmet compiler.

We give a C compiler high points for compatibility with other versions of C, for reliability, and for ease of assembly-language interface. But we are relatively indifferent to its speed. In fact, the more a project calls for speed, the less we are concerned with the speed of the compiler because we know that the critical routines will have to be written in assembly language.

None of the qualities that we consider most important for our applications were addressed in any of our published benchmarks, and I'm not sure how to devise a benchmark that could quantify them. Perhaps data such as "number of times per week documentation is thrown against wall" or "number of support calls returned per thousand" might be useful in evaluating a product. In any case, the point here is not that we ignored our own benchmarks and found the C compilers that are really "the best." We use the compilers that are most suited for our particular jobs. For people who want programs that they will write from scratch, that will execute quickly, that will require minimal assembly code, and that will take up minimal RAM (random-access read/write memory) space, the compilers we have been using may quite possibly be "the worst."

The Ascendancy of Waste

Benchmarks are best at measuring efficiency and speed. Efficiency, however, is threatening to become a dead issue. Efficiency means the amount of memory required to run a program. As technology sprints along, processors are being produced that can address huge expanses of memory. Soon, little children will have to teach their parents what "gigabyte" means. Meanwhile, the price of semi-

conductor as well as mass-storage memory continues to drop. Both trends drastically reduce the pressure to produce and use efficient programs.

One of the most remarkable indications of computer technology's advances over the past few years is the dwindling importance attached to program size. Not so long ago, programmers would spend months paring away a few kilobytes from a piece of code; but now, the programmer's time is valued much more highly than those kilobytes. Apple's Lisa is a monument to the enormous amount of RAM now routinely sacrificed to make programs more "user friendly." With this new attitude toward efficiency, a strong point of benchmarking has been made trivial.

Speed Thrills

With all the vast changes wrought by the stampede of technology, one relationship has remained untouched: time is money. This is true whether it is a programmer's time or a user's time. Therefore, the faster a program runs, the more time and money can be saved. However, there are limits to the extent that increased speed can improve a program. For instance, it does no good to have a word processor wait twice as fast for you to type your next character. For many applications, though, faster is better.

Speed is where benchmarks come into their own. Measuring overall speed, however, can be a little tricky. A compiler may be fast when it runs tasks out of main memory but slow when it does file handling. Even in the unlikely event that all other factors—compatibility, reliability, documentation, support—are equal, *you still* have to know which operations you are timing and which ones must be fast when you use speed benchmarks.

Job-Specific Benchmarks

Probably the best use of a benchmark is to measure the time it takes a given hardware-software combination to run a program that will actually be run in real life and represents the dominant use of the proposed system. If, for example, an engineering firm has an application that involves repeatedly inverting a big matrix, then the ideal benchmark would be a matrix inversion with representative sample data. This is, of course, a far cry from finding out how fast the same system can generate prime numbers.

The ideal benchmark is not a generalized exercise that can be published in a magazine and distributed to millions; it's a carefully planned demonstration in which the specific application intended for the product is simulated as closely as possible. Where I work, it is not unusual to receive test programs that we are to run and report on. The Department of the Army is particularly fond of this shopping technique. It goes to the initial trouble of developing a benchmark that fits its application, and the rest is up to systems houses. In effect, the Army is benchmarking us.

Upon receiving a custom benchmark task, a systems house really begins to earn its living. The benchmark is run on equipment that offers different levels of speed, cost, and versatility. If the job can be done on a fast but expensive disk emulator, we offer that option. Because most of our systems are based on the Compupro with a 16-bit, 8-MHz 8088 as well as an 8-bit 8085, we can sacrifice 8-bit compatibility in order to increase speed 40 percent by using a 10-MHz, 16-bit-only 8086 central processor. Another alternative is running the benchmark on an expensive hard disk that has a fast voice-coil-head actuator rather than a less expensive one with a slower stepper motor. We present all these trade-offs to the customer along with realistic timing data. The customer still has to make a choice, and in many cases it is an extremely difficult one; however, he doesn't have to choose blindly, guided only by a meaningless off-the-shelf benchmark.

But, you might say, setting up such a simulation is hardly a benchmark at all. It's a demonstration. The whole beauty of benchmarks is that you don't have to spend all that time designing tests and entering representative data. Benchmarks are supposed to be fast and decisive. They shouldn't be a lot of work—they should give you something for nothing. Right?

Wrong! That idea went the way of the free lunch. In most cases, you get out of a benchmark just what you put into it. The time spent designing a job-specific benchmark that suits your needs is insignificant compared to the time you will spend using the tool you eventually select.

Do generalized benchmarks have a place? Of course they do. Benchmarking is the great pastime of the computer world, the great sporting event for software hackers and hardware nerds. Benchmarks *are the* Olympics. You watch, you marvel, you enjoy. You root for your favorites and revile the opposition. You argue that the results were unfair and that the rules should be changed. You forget the results and lose bar bets to obnoxious friends with better memories. But you don't base major business decisions solely on benchmarks.

How to Make a Selection

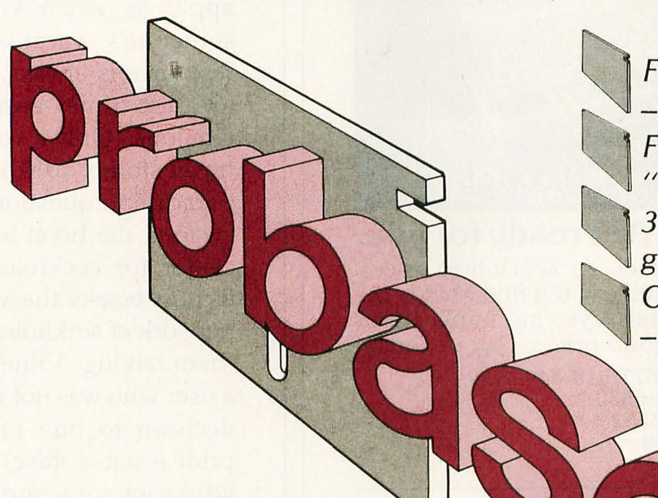
If you can't rely on generalized benchmarks, and you don't have the time or skill to design a job-specific benchmark, then how do you select a computer or a program? Unfortunately, it's not easy. You have to realize that a major software or hardware purchase is like a marriage. It is a long-term commitment for better or for worse. Marry in haste, regret at leisure.

There are three important ways to research a product, and you should use all three:

1. Read the trade magazines for reviews. You can usually judge the validity of a product review the same way you judge a movie review. If it is in-depth and genuinely enthusiastic, you probably have a good product. If it is superficial, full of cliches, and apologetic (the reviewer says the documentation looked good but there was not enough time to open it), then ignore the review, not the product. Don't confuse the product with the review.

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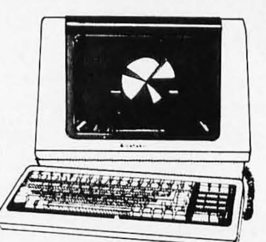
2. Talk to friends or colleagues or fellow members of computer clubs, and talk a lot. Most people are reluctant to admit that they wasted money on a product; it's stupid to waste money, and people usually want you to think that they're smart. The same rules apply as when you ask about someone's vacation. The first response is always, "We had the greatest time ever. Absolutely fabulous." Only if you start trading travel stories do you find that the paradise in question is a malarial swamp, the hotel is a convention center for cockroaches, and the airport boasts the world's largest network of sinkholes. Again, keep them talking. Value the advice of a user who was not involved in the decision to buy (and so whose pride is not at stake) more than the advice of someone who actually selected the product.
3. Find a reputable dealer. Good dealers are well aware that a major purchase is a marriage between dealer and client. In a good sale, the client returns and buys more goods and refers friends who in turn buy and buy again. This sort of sale enhances both the self-esteem and the bank account of the dealer and generally makes business fun. Good dealers love it if they sell you the right product, and they will often do some homework for you to make sure you make the right choice. They will certainly do more than look up some benchmark results. To a good dealer, selling you the wrong product is like driving off a cliff: there are a lot of exciting possibilities, but they're all bad.

These three rules are reliable ways of selecting software and hardware, much more reliable than the general benchmarks you see published so often. Stay true to these rules, and you'll be able to look beyond the numbers and break away from the bench. ■

Jerry Houston is vice-president of marketing at Gifford Computer Systems (POB 1917, San Leandro, CA 94577).

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Beyond MIPS*: Performance Is Not Quality

Two users examine the quantifiable aspects of system quality

by John M. Carroll and Mary Beth Rosson

Performance is the most common term of measurement used in the world of computing. Performance refers to the effective speed of a device, hardware or software. It refers to reliability. It refers to so many things that you could easily come to regard performance as a synonym for quality. But there is a danger in this—quality must not simply be equated with performance. Performance does not take into account usefulness or usability, which are critical determinants of the ultimate quality of a system, particularly a microcomputer system.

In this article, we consider three aspects of quality. First, we discuss the meaning of quality and emphasize the contributions of factors other than system performance as typically measured. Within this broader context, we consider how the quality of a computer interface might be analyzed. We focus on users' needs and on how readily those needs can be accomplished. We argue that high-quality devices are those that support the user's fluent accomplishment of typical tasks. Finally, we describe how an analysis of quality might be incorporated into the design process. Devices can be designed for high performance; we urge that they be designed for high quality.

* millions of instructions per second

What Is Quality?

Usually, when we ask "Does a device work?" or "How well does it work?" we intend the industrial-engineering sense. We presuppose an *ideal* operator. It is easy, though, to imagine examples in which this assumption is overly generous. A bicycle with pedals positioned so far from the seat that a *typical* rider cannot reach them may be a high-performance bike for that ideal operator, but something is seriously wrong with it for the typical operator.

Frequently, computer application systems are like that high-performance bike: neither usable nor useful. Imagine a new word processor with twice the processing power of previous systems and a minuscule probability of hardware defects. With respect to performance, it is rated a quality system; but if you are a novice and want to use the system to type and print a one-page letter, you may not agree with this rating. Very often, there will be no simple procedure to accomplish your goal; despite the "quality" of the parts, the pedals seem to be designed for people with far longer legs. Thus, you may need to sort through icons, negotiating selection and movement, single and double mouse clicks, copying dummy documents, and so forth. Or you may need to traverse a more rigidly structured, but equally inscrutable, hierarchy of menus or be faced with a vacant screen that awaits commands but gives no hints.

Consider a scene we have observed often in studying users of commercial word processors. The operator is presented with a menu of options immediately prior to seeing the text-input area. Under the menu is the following prompt: Type ID code to select CHOICE; press ENTER. The user need not in fact select any optional CHOICE to move to text input, but invariably the user does. Having done so, the user is once again prompted: Type ID code to select CHOICE; press ENTER. Again, the user selects an option (often reselecting his prior CHOICE). Indeed, this cycle of redundant selection and reselection can continue for many minutes. And unfortunately it accomplishes little or nothing. The default CHOICEs are satisfactory in most cases; CHOICE-looping only delays the goal of getting to the typing display (see references 3, 4, 8).

The issue of quality is not limited to inexperienced users. For experienced operators, measures of performance, such as processing speed, may indeed become more im-

portant determinants of quality; these users may operate in a mode in which variations in system capacity are more apparent (see references 6 and 10 for discussions of the effects of system response time on users' productivity). However, even for routine users, other factors are much more important. Good system performance may make a tedious procedure more acceptable, but it will not eliminate the negative impact on quality. Nor will performance alleviate the problem of long-term skill learning—often, experienced users fail to acquire the most effective methods for accomplishing their goals (see reference 9). In a high-quality system, these problems would be addressed not by improving system performance but by making the more effective methods transparent to the user and by making relevant procedures easy to learn and execute.

Even if the usability of a system is high, its quality might be severely impaired by its usefulness to its intended audience. For example, if a user is shy when it comes to writing about sensitive matters, or if a person cannot type fluently, an electronic mail system would not be useful. By the same token, if someone is principally concerned with filling in forms, then most word-processing systems would not be useful. Finally, if someone works in a highly interactive team environment, a calendar application without provisions for sharing data would be of very limited use.

The term "quality" has meaning only when considered from the perspective of real users performing real activities on a system. The level of performance in the context of an ideal user may contribute to quality considered from this perspective, but much more important is the extent to which the system supports users in the pursuit of their own goals (both what they want to do and how they want to accomplish it). How can quality, in this sense, be measured?

Measuring Quality

In order to measure the quality of a system, we need to know (a) who the intended users will be, (b) what they will want to use the system for, and (c) how they will want to achieve those goals. Such a description would turn the focus on users and their needs, which is essential to evaluating system quality. The measurement itself is made through psychological experimentation: empirical studies of representative users performing representative tasks.

The representativeness of the users and their tasks is key. The quality of a system designed to be used by secretaries cannot be assessed by having programmers try it out. Programmers aren't secretaries. The background knowledge that can be assumed for one group cannot be assumed for another. A system that is just fine for programmers could be a disaster for secretaries. For example, it is routine for programmers to invoke an application before using its function. This is not at all obvious to nonprogrammers. Secretaries with no computer experience might attempt to type their first word-processor document on the top-level control menu. (We have observed this kind of error with nonprogrammers learning to use a variety of word-processing systems.) Conversely, secretaries routinely specify pitch and style of type fonts; a system designed for such users could address such functions more technically than could a comparable system designed for use by programmers.

If one system elicits better performance on typical tasks by typical users, then that is the higher-quality system.

Just as background knowledge varies among user groups, so do their typical goals in using the system. Secretaries seldom compose text. Far more typically, they key in and revise text that someone else has composed. This arrangement would be reversed for typical programmers. Accordingly, testing the quality of a word-processing system for secretarial users would place relatively greater emphasis on keying and revision tasks than on composition tasks. And the reverse would be true for a word-processing system designed for programmers.

Typical Tasks, Typical Users

Indeed, the characterization of typical tasks and user groups can and should be more in-depth than our simple example. The tasks of legal secretaries differ from those of correspondence secretaries in many relevant ways. Typical tasks can be analyzed in greater resolution than composition versus transcription/revision: some secretaries may deal exclusively with one-page memos and letters; others may often transcribe lengthy technical reports. Assessing the quality of a system requires us to identify the intended users and their typical tasks and measure a representative group of such users performing such tasks with the system.

For a system designed for correspondence secretaries who typically type brief memos, a measure of quality would be *the average time required to type an average memo.* Two systems, both designed for this user group (possibly among other groups), could be compared on this basis. If one system elicits better performance on typical tasks by typical users, then that is the higher-quality system.

Of course, systems often provide a variety of functions intended for diverse groups of users. For these systems, different user groups must be demographically represented in any test and asked to perform the particular tasks typical of their group. If the principal group is secretaries and the secondary group is managers, then both must be proportionally represented in the tested sample of users. The secretaries might be asked to transcribe memos and the managers might be asked to prepare performance plans.

Our considerations don't stop there. Users vary not only in their job-related backgrounds but also in their computer-related backgrounds. Systems optimized for correspondence secretaries with no computer experience might be less

than optimal for members of the "*same*" user group who are experienced with word processors. When we begin to imagine the interactions of experience on different systems, this issue can become quite complicated. Nevertheless, we must pay attention to distinctions in system quality for users of different experience levels. Thus, one measure of quality for a word-processing system intended for secretaries might be the time required for a secretary without computer experience to create and print her first letter; another measure might be the time required for an experienced secretarial user to create a table with a complex format. In a quality system, basic functions are learned easily, which aids the initiation of novices. But just as important, advanced functions should be acquired *naturally* when appropriate, which supports productivity and the development of expertise in the longer term.

Current system designs in many cases do try to accommodate distinctions between different experience and expertise levels (as well as some of the other distinctions we have discussed). However, in no case has the quality of a design been seriously ascertained. The IBM Displaywriter provides a menu interface to make learning easier and a menu-bypass facility to support fluent and productive skilled use. The Apple Lisa system presents an interface organized by the desktop metaphor for ease of learning and Apple-key commands for the convenience of more experienced users. We would argue that although both systems are addressing the right issues and adopting reasonable approaches to these issues, their success is unknown. The quality of both systems on these grounds (and others) must be determined empirically.

Analyzing Quality

We have argued that system quality is more than mere performance. We have tried to show how usability and usefulness are the final determinants of system quality and how they can be assessed empirically. But we can do better: we can try to understand the components of usability and usefulness; we can try to understand what quality is.

Our starting point is *how* users want to achieve their goals. We want to expand the framework presented in the preceding section to include consideration of the particular approaches, methods, and subskills that are employed when users try to address a goal (such as typing a buck slip) with an application system. Knowing that 90 percent of correspondence secretaries can key in and print out a one-page memo in less than 15 minutes provides an assessment of quality. But knowing a larger number of more specific facts (e.g., 85 percent make the mistake of miscoordinating coded keypress commands at least once in the course of requesting a print job to be queued) provides a more detailed

assessment of quality.

Breaking down macro-level tasks, like keying in and printing out a buck slip, into subtasks, like queuing a print job, provides an insight into quality that is deeper than that provided by simple pass/fail tests. Two systems might be indistinguishable with respect to how long comparable groups of users take to perform comparable tasks, but the systems might differ substantially in *where* the users' time went. Queuing a print job might present the user with a variety of specific problems in one system: awkwardly worded prompts, icon-cluttered displays, inconvenient defaults, multiple-keystroke commands, etc. In another system, the problems might pertain to the command or menu protocol for selecting the pitch and style of type fonts. From the macro-level standpoint, the quality of the two systems is equal; we have assumed that in both cases an identical proportion of representative users can successfully accomplish a representative task. But from the more detailed level of *how* the users accomplish particular subgoals, there is a trade-off in quality between components of the macro-level task.

A trade-off is not a choice between equivalents. The relative usefulness of the two systems we have imagined might differ considerably. The system for which type-font selection was difficult might still be more useful than the system for which queuing a print job was difficult. After all, being forced to accept default pitch and style is not as great an obstacle to getting real throughput as is being unable to queue a print job. The default type font may not be exactly right, but it will always be better than no printout at all. The relative difficulty of system subtasks must be collated against the goals people bring to the situation in order to assess the usefulness of the system (see reference 2).

In the short term, it may be satisfactory to know that typical users spend an average of 15 minutes keying in and printing out a buck slip. After all, if the state of the art is 18 minutes, you might realize a productivity savings of about 15 percent in the system of *higher quality.* But in the longer term, we need to understand better where the 15 minutes (or the 18 minutes) is going and how it affects the usefulness of the system. Indeed, understanding those details is the key to improving the quality of systems.

Designing for Quality

It will probably come as no surprise when we suggest that an understanding of system quality, along the lines indicated earlier, might be incorporated into the design of systems. After all, if we are not satisfied with merely benchmarking macro-level user tasks, why stop with benchmarking subtasks? If we can understand the detail of system quality, then we ought to be able to exploit this understanding by designing better systems. Addressing the finer grain of user subtasks affords us a more analytic measurement of sys-

tem quality that can contribute directly to the designing of higher-quality systems. Although this discussion has focused on the assessment of completed systems, many of the measurements we have discussed could be made on mock-ups of interfaces, on simulations of systems, and on prototypes.

We believe that making such measurements during the early stages of the system-development process is the only way to ensure the design of quality systems (see references 5 and 7). Consider, for example, the implementation of contextual dependency in a menu-driven word-processing system. The notion is that only functions that make sense in a given context are available to the user. The payoff is obvious: it protects the user from the often costly errors associated with inappropriate menu selections (reference 3).

But the implementation of the principle is not so obvious. We could incorporate the dependency either in the *display* of options or in their *selection*. In the first case, the physical appearance of the menu would vary from mode to mode and the user would be faced with possible problems stemming from a failure to recognize the mode and its inherent limitations on functions. In the second case, the physical appearance of the menus is constant, but its response to the user's action varies: sometimes certain functions are "not available," leading to possible user frustration. The choice of a good solution to this design issue cannot be known a priori, nor can it be indicated through macro-level usability benchmarking. The ultimate choice will be very much a function of the details of the application, the menu content, and the instances of contextual dependency most likely to be encountered by a typical user.

The computer industry will very likely continue to focus on the goal of improving system performance. And it clearly should; performance factors like reliability and response time have a variety of obvious, and not so obvious, effects on user satisfaction and productivity. (The exact nature of these effects is still a matter of controversy; see references 1, 6, 9.) But increasingly there is an awareness that mere performance is not enough, that it is not the same thing as quality. As computers become tools and toys for everyone, their ability to adapt to human needs and propensities becomes the principal determinant of real system quality. We have outlined a simple, yet systematic, empirical approach to the measurement, analysis, and design of system quality. We know of no scrupulous case studies of this approach, but the momentum of the entire industry is overwhelmingly heading in this direction. In the next few years, the study of system quality should be one of the most active areas in computer science research. ■

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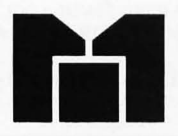
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Some helpful guidelines borrowed from a successful hardware model

by Brian Boyle

On the grand scale that measures difficulty, relevance, and necessary skills, the job of software performance evaluation falls somewhere between the role of test pilot and drama critic. While obviously subjective, the criteria for evaluation must be rigorously and narrowly defined: it is not the reviewer's task to rank the intrinsic social or intellectual values of, for example, Lotus 1-2-3 versus Pac-Man, but rather, to report to prospective consumers the quality of the rendition of the subject matter.

In this article, I'll try to document some of the criteria used for software performance evaluation. Though not an easy task, there are some straightforward approaches. Also included is a text box that discusses a surprisingly accurate means of evaluating a processing system's performance. The knowledge gained in successfully constructing a hardware performance measuring tool can be used to guide reviewers in evaluating software.

The evaluation of software application packages is only one of the categories of analysis performed at Gnostic Concepts Inc. We regularly examine computer hardware, operating systems, and support, training, and distribution schemes, as well as market data and projections. At either end of this spectrum are areas of interest readily amenable to quantitative analysis. At the microcomputer end, a system based on an Intel 8088 processor running at 4.77 MHz (megahertz) can perform a specific number of 32-bit ADD instructions in a given time. A 5¼-inch Winchester disk with known rotational speed, head-movement time, and transfer rate can access a known number of fixed-length records in a certain time. At the market end, statistical analyses can accurately determine and predict the number of dentist's offices in the United States today and during the next decade.

It would thus be tempting to assume that a software application package lying somewhere along this path from microcomputer to market can be treated objectively and numerically using the same tools. In a nation of numbers, the ultimate goal of any evaluation is usually to obtain a number, set of numbers, or semi-quantitative indicators.

Quantifying Hardware

Despite the obstacles, there is a possible software performance-evaluation methodology for arriving not at a single (scalar) value but a characteristic set (vector) of values, based principally on experience in hardware evaluation. The accompanying text box depicts the relatively "simple" methodology for arriving at a single Figure of Merit (FOM) for a given hardware configuration. Clearly, a single value is an oversimplification that overlooks many specific advantages and disadvantages of the system within a particular environment: a system ideally suited for video games is different from a system optimized for scientific array computation or business database processing. Realistically, however, a CAD (computer-aided design) system for integrated circuits, for instance, has many of the requirements of each, so a single scalar value has some foundation in reality.

Obviously, quantification of something as complex and personal as personal computer application software is far more difficult than hardware evaluation, but you have to start somewhere. Lacking any other scale, potential users still want to know "what's hot and what's not," even when the limitations of such an oversimplification are spelled out.

Software Evaluation

Of course, there are aspects of software performance evaluation that lend themselves to the same kinds of quantitative techniques that are used in the hardware-evaluation approach discussed in the text box. Like test-piloting, quantitative limitations are tested, wherever feasible, both up to and beyond their stated limits: *up to* validates the claim; *beyond* evaluates how user friendly, or user hostile, the system is when pushed over the edge. Response times under given loading conditions can be measured quite accurately: using a personal computer's RS-232C port allows it to simulate both a terminal and a tireless, methodical user/evaluator on another system. Not only can much of the process be automated, but

thousands of measurements accurate to the millisecond are possible.

Still, there remains the problem of assigning interpretation to these quantitative values. What is an acceptable response time? To whom? When? The problem wanders out of the realm of measurement and into the twilight zone of experimental or industrial psychology, management science, or opinion sampling—all on the borderline of applied guesswork. Yet, despite the obvious difficulties and differences, the hardware performance-evaluation model provides useful insights into an approach, or set of approaches, to software performance evaluation. At the very least, there is a suggestion of a divide-and-conquer approach in which the separate factors and terms of the software are evaluated and weighed individually before recombination.

Perhaps the most useful concept transportable from the hardware model is the suggestion of the units of measurement. The units in the hardware FOM are the square root of the product of the word width (in bits) and the (practical) memory address length (also in bits). All of this is divided by nanoseconds and multiplied by a dimensionless value purportedly relating the "value" of bits-out relative to bits-in.

Intellectual Leverage

The last factor, the "value," or "information multiplier," characterizing the intellectual advantage of the machine, is closely analogous to the mechanical advantage factor of simple machines like levers and *pulleys*, in which you trade increased motion for increased force. A good computer system (hardware plus software) is expected to give us what Xerox scientist Lynn Conway called "intellectual leverage." If the bits/second were liters/second or electrons/second, then information flow, or throughput, would be fluid flow or current in amperes. When multiplied by the knowledge-enhancing "force" (pressure or voltage), the resultant value is work/second or power (equivalent to watts).

Any software performance measurements should be consistent with this line of reasoning. Raw performance measurement applies it directly. A typical data-processing program can be rated by the product of:

1. the *number* of records processed in a given time
2. the *size* of the records in bits (more often bytes)
3. the *complexity* of the structures manipulated, usually the order or binary logarithm of the number of branches in the graph of the data structure represented as a binary tree
4. the *transformation factor* or ratio of the information-theoretic complexity of the records output compared to those input

The concept of the *order* of an algorithm is frequently used in theoretical analyses that compare different sort, search, merge, and transform techniques. A sequential search, for example, is said to be of order(n) because its run time increases linearly with *n*, the number of items in the list. A binary search, in which the search domain is narrowed by one-half at each step, is said to be of order(log(n)) because its run time increases by only one step for each power of two, or doubling, of the number of items.

Of course, the complexity (and run time) of each step is typically greater for the binary search, so the sequential search may actually be faster for short lists, but for a sufficiently large *n* we know that the order will dominate algorithmic performance. Similar theoretical performance estimates can be made for frequently used features within an operating system: context-switching (between processes), interrupt-handling overhead, and subroutine or procedure calls are examples that account for a majority of the instructions executed in typical general-purpose computer systems.

Theoretical, Experimental, and Observational Evaluation

When it comes down to it, the modes of software evaluation are the same as those of physics. Simple behavior of small numbers of well-understood features can be theoretically modeled and predicted, such as the reflection of light, the collision of billiard balls, and the surprisingly indicative hardware FOM. Then there are the properties that can be measured experimentally, like the speed of sound, light, or programs under specified conditions. Finally, there are those aspects like astronomy, cosmology, human psychology, and other observational sciences, in which you are unable, or not allowed, to take apart the mechanism to experiment, and your theories are never really verifiable. This last aspect is the most difficult and most challenging.

Another lesson to be learned from physics is the uncertainty principle that says (among other things) that to some degree the act of measuring a phenomenon affects the outcome and changes the result. You can see this in the case of a program-performance monitor running on the same machine, and competing for the same resources, as the program it is attempting to evaluate. Such internal instrumentation of a program, in which checkpoint code is inserted into the program source and compiled with it, can be very revealing, but you must remember to correct for the effects of the monitor itself, both in timing and, even more subtly, in operation.

An actual relevant side effect of the uncertainty principle is the unspoken realization that the whole is greater than, or sometimes less than, the sum of its parts. At the trivial end of the spectrum, a dynamite set of programs—word processor, spreadsheet, graphics, database, etc. —is a dud if the components each use mutually incompatible formats. A little farther up the scale, if they communicate only through disk files or, worse yet, files *and* conversion programs, they may add up, but they certainly don't multiply or enhance one another. A major feature of the Unix operating system from Bell Laboratories is not so much its multiuser as its multiprocessing capabilities; it uses the pipe mechanism to pass data among concurrently running programs without passing through a vastly slower disk file. Finally, there is semantic incom-

Text continued on page 180

Quantifying Processing System Performance—the MilliVAX

The Figure of Merit

The somewhat formidable Figure of Merit (FOM) formula in table 1 is based on some common-sense concepts that measure "work per time," just like the story problems of grade-school days: Tom can chop a cord of wood in three hours, Jerry in four hours, and Bill in two hours. How long . . . ?

To determine how much wood the woodchoppers could chop if they chopped together, our math book said to take the reciprocal of the sum of their rates in cords/hour, for a combined time of 12/13 hour per cord. We were also taught to assume independence and ignore the practical facts that Tom and Jerry can't stand to work together and that "Wild Bill" is fast but too dangerous to work with.

The hardware FOM is simply a quantitative measure of how much data (in bits) can be fetched and stored in a given period of time (in nanoseconds) multiplied by the amount of value-added work that can be performed on that chunk of data to transform it into useful information. The FOM is a surprisingly accurate approach for predicting processing-system performance. For evaluation purposes, the processing system does not include fetch and write cycles from mechanically dependent memory devices such as floppy disks, hard disks, and tape. Nor does it consider input (e.g., keyboard) or output (e.g., printer) interaction times. On-board memory access, including any cache memory, is included.

You could arrive at the denominator (time) using raw MIPS (millions of instructions per second) figures, but such numbers offer a precise yet inaccurate measure of system performance, as misleading as Wild Bill's performance as a wood processor.

A more complex but accurate denominator for the FOM formula takes into account the several levels of memory in most computer systems. The typical processor clock rate and memory cycle time can be misleading if used blindly: the memory may not always be as fast as the processor or synchronized (in step) with it, resulting in wait states. Conversely, on many microcoded processors, memory fetches are much faster than typical instruction execution time.

Using a technique developed in the days when processors were much faster than memory, many sophisticated systems employ a fast auxiliary cache memory between the processor and main memory. The effectiveness of the cache in minimizing accesses of a slower main memory depends on the "hit rate"—the average fraction of memory references to data or instructions that are in the cache. The cache's overall utility is a product of its speed and probable hit rate; the latter depends on the cache size and characteristics of the program(s) being run.

Smaller systems generally lack cache memory but have internal registers with even faster access times that the FOM characterizes by the interregister add time. In assembly-language code and good compilers, these registers are used as a sort of "minicache" for intermediate results, offsets, bases, pointers, counters, and other frequently used values, so that the number of such registers and their flexibility

FOM*	$= K \times n_p^{2/3} \times (1 + n_c)^{1/2} \times W_{eff} \times W_{inst} \times W_{addr} / T_{avg}$
Where:	
K	= a constant to force the "value" of a VAX-11/780 to 1000.0 milliVAX
n_p	= the number of main (general-purpose) processors in the system
n_c	= the number of special-purpose coprocessors in the system (if any)
W_{eff}	= the effective processor word-width (in bits)
	$= (W_{int} \times W_{ext})^{1/2}$
Where:	
W_{int}	= the internal word-width, usually the register-length
W_{ext}	= the external word-width, usually the data-path or bus-width
W_{addr}	= the effective processor typical maximum memory address-width (in bits)
	$= \log_2 (M_{addr})$
Where:	
M_{addr}	= the effective useful maximum main memory address
	$= (M_{min} \times M_{max})^{1/2}$
Where:	
M_{min}	= the useful minimum main memory configuration
M_{max}	= the useful maximum main memory configuration
W_{inst}	= the effective processor instruction field-width (in bits)
	$= \log_2 (n_{inst})$
Where:	
n_{inst}	= the effective number of distinct operable instructions
	$= n_{mri} \times n_{mod} - n_{nul} + n_{nmr}$
Where:	
n_{mri}	= the number of separate memory reference operation codes
n_{mod}	= the number of separate memory address modes
n_{nul}	= the number of meaningless combinations of op-codes and a-modes
n_{nmr}	= the number of separate nonMRI(memory reference instructions)
T_{avg}	= the average operation cycle time normally executed by the processor
	$= T_{ira} \times R_{reg} + (T_{ira} + T_{amr}) \times (1 - R_{reg})$
	$= T_{ira} \times R_{reg} + T_{ira} + T_{amr} - T_{ira} \times R_{reg} - T_{amr} \times R_{reg}$
	$= T_{ira} + T_{amr} - T_{amr} \times R_{reg}$
Where:	
T_{ira}	= the inter-register ADD time (in nanoseconds)
R_{reg}	= the register access ratio (what fraction of references are to registers)
	= 1 − Probability that an instruction references memory (not registers)
	= 1 + 2 × P(reference is to main memory) − 2 × P(reference is to register)
	$= 1 + 2 \times (1/\log_2 (M_{addr})) - 2 \times (1/\log_2 (n_{reg}))$
	$= 1 + 2/W_{addr} - 2/\log_2 (n_{reg})$
Where:	
n_{reg}	= the number of general-purpose registers of width W_{int}
And:	
T_{amr}	= the average cycle time to reference main or cache memory
	$= T_{cam} \times R_{cam} + T_{mem} \times (1 - R_{cam})$
Where:	
T_{mem}	= the main memory cycle time (in nanoseconds)
T_{cam}	= the cache memory cycle time (in nanoseconds)
R_{cam}	= the cache "hit-ratio" (what fraction of memory references are to cache)
	= 1 − cache "miss-ratio" (probability a reference to Main not in cache)
	= 1 + 2 × P(reference is to Main Memory) − 2 × P(same address in cache)
	$= 1 + 2 \times (1/\log_2 (M_{addr})) - 2 \times (1/\log_2 (M_{cam}))$
	$= 1 + 2/W_{addr} - 2/\log_2 (M_{cam})$
Where:	
M_{cam}	= the cache memory size in Kbytes

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Table 1: *The processing-system figure of merit (FOM).*

determine their hit rate.

For simplicity's sake, our FOM does not include the opposite end of the speed spectrum, mass storage—usually disk. Disk storage is normally the rate-limiting factor in most small computer systems. This lowest level of memory is classified as level 5, after registers, cache, main, and optional level 4 memory (typically bubble memory), CCD (charge-coupled device), or disk-cache devices.

The greatly improved throughput of the hard disk owes less to its greater size than to its much faster random-access speed. This is not to be confused with the transfer rate, the speed of loading data once the proper track and sector are reached, which is usually quite fast. Random-access time is the search-plus-seek time necessary to reach the data in the first place, usually measured in tens or hundreds of milliseconds. Admittedly, the chunk of data transferred is usually large, so the vast initial overhead is spread across the hundreds or thousands of bytes accessed. Nonetheless, speed and volume of disk reading and writing utterly dominate most business applications.

Parameter	Description	Units	DEC VAX 11/780	IBM PC XT
FOM :	Figure of Merit	mVAX	1000.0	79.2
n_p :	Number main processors		1	1
n_c :	Number of coprocessors		1	1
W_{eff} :	Word width, effective	bits	32	11.3
W_{int} :	Word width, internal	bits	32	16
W_{ext} :	Word width, external	bits	32	8
W_{addr} :	Width, useful address	bits	21	17.7
M_{addr} :	Memory, useful configuration	Kbyte	2048	202.3
M_{min} :	Memory, useful minimum	Kbyte	512	64
M_{max} :	Memory, useful maximum	Kbyte	8192	640
W_{inst} :	"Width" instruction set	bits	8.8	7.7
n_{inst} :	Number useful operations		445	210
n_{mri} :	Number mem-ref operation		96	64
n_{mod} :	Number addressing modes		16	12
n_{nul} :	Number null combinations		1218	630
n_{nmr} :	Number non MRI instructions		127	72
T_{avg} :	Time, average operation	nsec	585	1928
T_{ira} :	Time, inter-register ADD	nsec	515*	1677
R_{reg} :	Register "hit-ratio"	(%)	.57	.40
n_{reg} :	Number full-word GP-registers		14	7
T_{amr} :	Time, average memory-ref	nsec	165	420
T_{mem} :	Time, memory cycle	nsec	400	420
T_{cam} :	Time, cache access	nsec	150	00
R_{cam} :	Cache "hit ratio"	(%)	94	00
M_{cam} :	Cache memory size	Kbyte	8	00

**A combination of integer and long ADD.*

Table 2: *A sample Figure of Merit computational value for the VAX 11/780 and the IBM PC XT.*

Work Per Time Still Works Best

As you might expect from a work-per-time measure, the denominator of the FOM expression expresses a typical mean data access time, the average of the access times for the various memory levels weighted by their projected, relative frequencies of use. The numerator expresses "work" and is a function of word size (width of data manipulated per access) and memory size (how much data you can stuff in memory without special addressing tricks or faulting to the next level of memory). This raw volume of data is multiplied by the power of the instruction set, a value indicating how few instruction cycles are necessary to accomplish a single high-level operation.

None of these factors can reasonably be read directly from a product's specification sheet. Word length, for example, could be taken either as the internal register length or the external data path width, which may be different. As an empirically validated compromise, the FOM uses their geometric mean (the square root of their product). This yields the expected 8 and 16 for the symmetric 8085 (8 by 8) and 8086 (16 by 16), respectively, but yields a "word length" of 11.3 for the 8088 because of its asymmetrical 8-bit external, 16-bit internal architecture.

The geometric mean is similarly used as a normalizing and scaling function to compute a reasonable memory-size parameter from the minimum and maximum memory configuration for a system. Taking the binary logarithm of this number converts its units back to bits, namely the word width required to address such a memory configuration. Experimentally, this turns out to be a much better measure than the theoretical maximum address range, which may go as high as 2^{24} or even 2^{32}.

The final factor in the formula, the power of a system, may seem the most technically obscure, subjective, or simply arbitrary. All other things being equal, the processing capability of a system obviously increases with the size of its instruction set, but certainly not in direct proportion.

As important to many compiler designers as an instruction set's size is its orthogonality, the fraction of potential instructions that are actually meaningful and useful. Like words in the English language, the frequency of instruction use follows (approximately) a logarithmic distribution: the most common eight instructions (or words) occur as frequently in common usage as the remainder of the most common 64.

This is the rationale for applying the $\log_2$ function to the total number of meaningful combinations of instructions, address modes, etc. The binary logarithm of the full set of combinations captures the log-normal frequency of instruction use and the advantages of symmetrical architectures such as the National Semiconductor 16000. Table 2 is an example showing the values used in the FOM computation for two typical processing systems.

MilliVAX versus the Real World

Does the hardware FOM actually correspond to anything we can relate to in the real world? In scanning any recent trade journal it is virtually impossible not to catch at least a dozen bar charts comparing brand-X supermicrocomputer to the DEC VAX-11/780, particularly in a Unix environment. If Helen of Troy possessed "the face that launched a thousand ships," then, to me, a reasonable unit of feminine beauty would be the milliHelen—the precise amount of beauty required to launch one ship. Similarly, the FOM constant, K, can be adjusted so that the ubiquitous VAX-11/780 has a figure of merit of precisely 1000 to create the semiwhimsical unit called the milliVAX, in which all

Text box continued on page 180

Text box continued from page 179:
small systems can be measured.

FOM Agrees with Actual Performance

Not surprisingly, the computed FOMs for various microprocessor-based systems agree with the marketing hype only as to relative performance, yet even the most advanced supermicrocomputers reach only a few hundred milliVAX. A bit more surprisingly, the FOM value seems to predict rather accurately the number of users that can be supported concurrently with reasonable responsiveness. Each user seems to require about 20 milliVAX as an absolute minimum, 30 or 40 for comfort, 60 for high performance, and hundreds for certain computationally intensive programs.

On this scale, a VAX-11/780 would support 50 to 64 users minimally, 32 comfortably, and 16 to 20 with high performance. At the low end of the scale a Z80-based personal microcomputer rated at 30 milliVAX is acceptable for one undemanding user; for comparison, a DEC PDP-8 (the first commercially successful minicomputer, with 4096 12-bit words of memory) has a value of 30 milliVAX and supports one to three users. The IBM PC provides 80 milliVAX (actually sufficient for 2 to 3 users, but not configured as such for marketing reasons). The Altos 586 enhances this to 130 milliVAX and five users by employing the full 16-bit 8086 processor and twice the PC's typical memory. Finally, most of the M68000-based, cache-enhanced supermicrocomputers vying with VAXs hit the charts at 200+ milliVAX, for a realistic 12 to 16 users. The point is that the FOM is actually a reasonable indicator of system capabilities.

Text continued from page 176:
patibility, in which the commands/keystrokes in one program mean different, even conflicting, things in another.

How do you quantify the benefits of compatibility? Again, physics has a model: the RMS (root-mean-square). A hundred violins sound only 10 times as loud as one, because they are not "in step" and (like incompatible programs) combine destructively nearly as often as constructively. Rather than adding end to end, they add "at right angles," since any two vectors are randomly oriented with respect to each other.

The length of the diagonal so formed *is given by* the Pythagorean theorem as the square root of the sum of the squares, or RMS. The combined value of cooperating programs is directly additive, or even multiplicative, when they actually support each other. Totally random combinations of mutually incompatible programs can be summed using the RMS value.

Software Evaluation Criteria

Once the errors and effects of measurement are taken into account and methods for rationally combining individual component values are determined, the basic components of evaluation must be specified. The following three Cs should be tested by any software performance-evaluation scheme:

1. Correctness of the operation: does the program (or system) do all that it is intended or is claimed to do with no side effects?
2. Completeness of user support: are the documentation, on-line aids, tutorials, training, and other aspects sufficient for operation?
3. Consistency of the package: is there a uniform conceptual model and consistency of actions and commands that minimize ambiguity?

For correctness, first check all the specifications you reasonably can to determine whether the program does all the things it claims to. Second, check that the program doesn't do anything it is *not* supposed to do under both ordinary and exceptional circumstances. Third, check to see that the program always does the same things at the same point, regardless of how that point was reached. This so-called Markovian behavior often is the bane of ordinary testing procedures.

The problem with both the second and third requirements is that programs tend to be tested by programmers. Programmers do not necessarily think like unskilled users, and even they gain expertise after some time.

Short of an endless supply of new users or an eraser for certain sections of the brain, the only way to simulate the bizarre states users may get themselves into is by methodically testing the progression from state to state, typically using a personal computer-based user simulator, running a program called a finite state machine (FSM.) Such a program, or checklist for human use, assigns a state number to each conceptual state the program occupies, as determined by its previous inputs or conditions. It then determines experimentally the (possibly) new state reached for each possible input. A well-behaved system has only as many states as are conceptually distinct—when a word processor is in a command mode, for example, it should not matter whether the last command was an ADD or DELETE, unless the difference is necessary (e.g., for an UNDO command).

Completeness of the user support is a frequently overlooked aspect of the system-evaluation process. (Shame on those systems analysts



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who fail to recognize that the user is part of the system.) Support may be categorized as external or internal and passive or active.

Manuals and other documentation are external/passive and should realistically be divided into three levels for three audiences:

- Level 1 (why) is a managerial overview describing the purpose of the program/system, its capabilities, and its limitations.
- Level 2 (how) is an operational guide to the use of the program/system, step by step, function by function.
- Level 3 (what) is the technical reference manual for the programmer or experienced user, detailing the intricacies of each function, the functions' idiosyncrasies and implementations, as needed.

Such manuals and accompanying materials (such as key caps, templates, reference cards, etc.) should meet reasonable standards: Is the text clear, complete, and readable in normal English? Are there clear and useful graphics of proper size and color? Is there a table of contents, an index, and a glossary of terms?

Training (live, video, or audio) is external/active and may occur at multiple levels, depending on user experience and sophistication:

- Level 1 (novice) explains the routine capabilities and the handling of the normally encountered exceptions in the normal fashion (usually "manual" rather than "automatic" mode)—those in which operator errors are harmless or easily recoverable.
- Level 2 (occasional) explains the time-saving and powerful shortcuts that bypass much of the novice-level error checking.
- Level 3 (expert) explains everything else about the system.

Menus and static Help screens are considered internal/passive because they provide support for the user from inside the system but are not generally context-sensitive—they *are* Markovian in that they read the same regardless of where the user is in the program's operation or how the (usually confusing) state was arrived at.

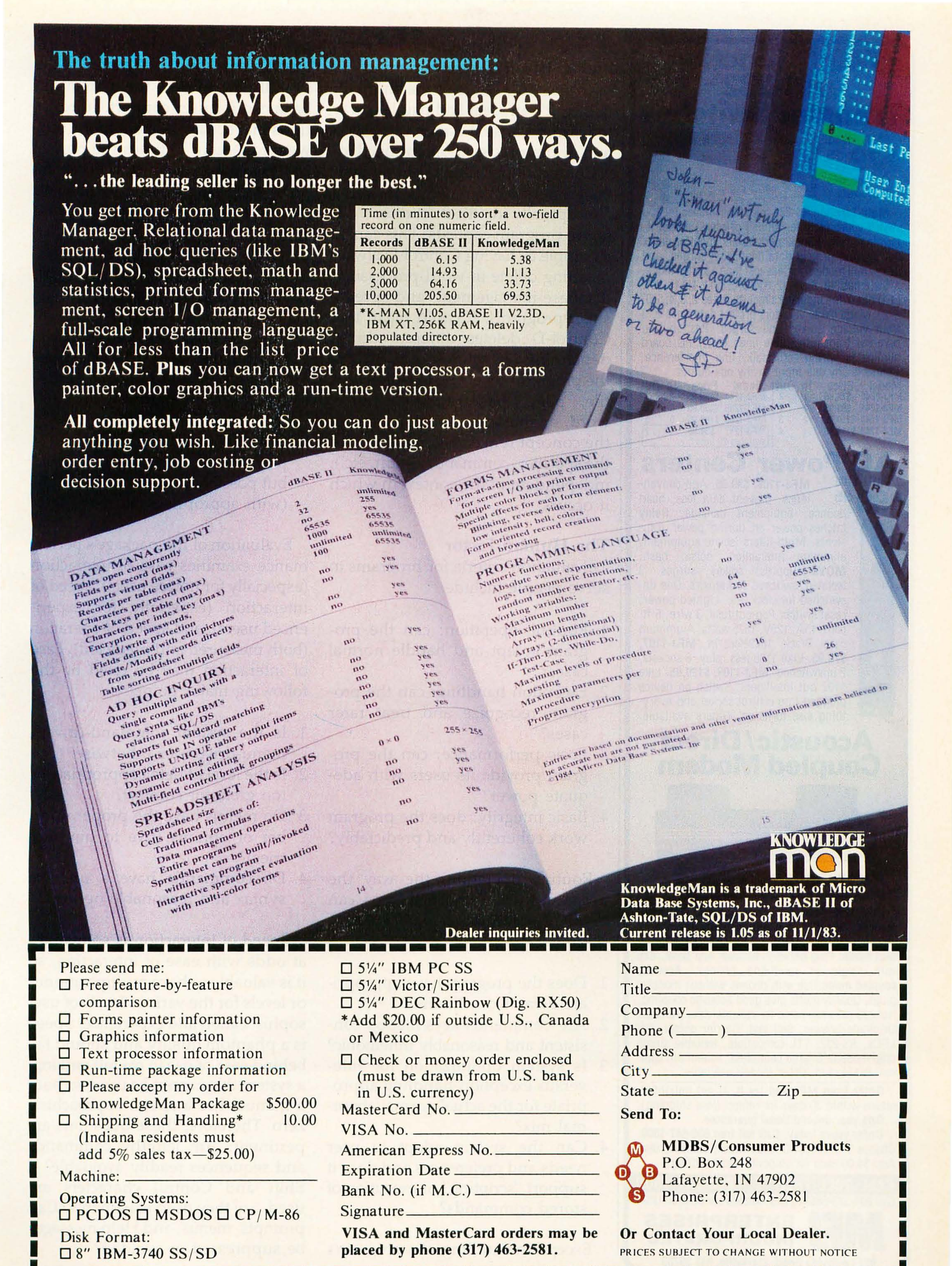
On-line context-sensitive Help messages take into account where the cursor is (what field of what screen of what program) and possibly how the user got there. Ideally, when an input is disallowed by the system, these Help messages reference the offending portion of the input and explain what is wrong with it. Better still, there is user control over the explanatory verboseness versus cryptic terseness of the system, depending on the user's current level of experience (novice, occasional, or expert).

Such internal/active on-line user aids (Help messages, menus, and tutorials) should comply with certain behavioral expectations for easy use; for instance, is the Help or menu transition-graph a hierarchical tree? Do the Help and menu structures have escape mechanisms? Are the context-sensitive Help messages and menus accurate?

Consistency, the third C in the software-evaluation checklist, is the best predictor of how well the user will get along with the program/system. While, as Emerson said, "a foolish consistency is the hobgoblin of small minds," a uniform conceptual model smooths the user's interaction with the system. Unpredictable behavior, whether in a human, a program, or a St. Bernard, is an impediment to understanding.

A good program relates to people who sometimes do make mistakes they would like to recover from and who do not always refer to things in the same way. An "undo" facility, where practical, is far better than merely asking five times whether the user is absolutely, positively, sure that all those files should be deleted. After a while, such redundancies merely irritate, and the overload of too many warnings actually reduces the attention paid to them.

Aliasing, allowing the same command or option to be expressed in different ways, is a human touch with real value to the novice and occasional user. If one form is faster or



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more efficient than others, it doesn't hurt to have the system remind the user once in a while of the shortcut; in fact, it's an ideal and painless way to learn because it hands the user a tool at the precise moment needed.

Context dependence or independence refers to commands meaning conceptually identical actions in different program contexts. This can be as simple as having Control-D always meaning delete in word-processing, database-management, and spreadsheet programs. It could mean that Control-D deletes different things depending on where the user is in the program—referring to a directory, file, page, paragraph, sentence, word, or character. The point is that the concept remains consistent with the specifier (command, option, etc.), independent of the context in which it occurs.

The Human Factor

Evaluation criteria for programs to serve people include:

1. Routine operation: can the program accept and handle normal cases?
2. Exception handling: can the program recognize and treat rarer cases?
3. Basic performance: can the program provide its users with adequate power?
4. Basic integrity: does the program work coherently and predictably?

Routine operation, the way the program works in normal cases, can be rated according to a checklist of pertinent questions:

1. Does the program have appropriate default conditions?
2. Are commands/keys/menus consistent and reasonably mnemonic?
3. Is system optimization for rule- versus exception-handling appropriate for the actual normal/abnormal mix?
4. Can the system adapt to user needs and preferences and does it support "scripting" or execution of stored commands?

Exception handling, the program's treatment of various levels of less frequent cases, should be geared to the overall efficiency of the system but balanced for user comfort. If exceptions that occur 1 percent of the time were to require 10 times the normal processing in order to save 10 percent processing on the other 99 percent, the trade-off would be wise, because 10 times .01 plus .9 times .99 is less than one. The following useful questions can be asked to rate exception handling:

1. Can the user undo errors?
2. Can the user switch between normal and exception modes of processing—for example, between "command" and "data" modes?
3. Does the program allow a user to perform all "seemingly unwise," but possibly necessary, operations (with appropriate *warnings*)?

Evaluation of the package's performance examines ease of interaction (especially for novice users), speed of interaction (especially for experienced users), and speed of operation (both measured and predicted). Ease of interaction may be rated by the following major points:

1. Is the system command-driven, menu-driven, or otherwise?
2. Is the level of detail appropriate or too great for comfort?
3. Do menus have the proper number of options (five to nine entries)?
4. Do commands have a uniform syntax and reasonable options?

Speed of interaction is sometimes at odds with ease of interaction, so it is valuable to have multiple modes or levels for the various levels of user sophistication and experience. Speed is a phantom quality and should fall behind ease of use in overall ranking; a system that cannot be used without a manual has a speed approaching zero. Therefore, these questions are pertinent: Are lengthy commands and sequences readily avoidable? If Shift and Control characters are used, are they used reasonably? Can prompts, menus, and Help messages be suppressed or avoided?

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The CP/M operating system, an 8080, 8085, or Z-80 microprocessor, and 32K RAM are required. Note: Double Density drives can read Single Density diskettes.

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Speed of operation has already been discussed from the system's point of view, but what happens "when the ball is in the user's court"? The very fact that the system typically waits while the user thinks, and then rushes to catch up, is a problem with many interactive programs that cannot be solved except at the operating-system level. Ideally, in menu and similar lengthy disk-fetch and screen-painting sequences, if a 2-second wait after 10 seconds of deciding is unacceptable to the user, all (five to nine) menus possible at the next lower level can be prefetched in preparation for the user's choice. Thus, response can be improved when the operating system allows "interrupt"-type operation.

The following questions help point up speed traps in a program:

1. Is inter-key response time acceptable in all circumstances?
2. Is the command/menu-selection processor response acceptable?
3. Is the disk-fetch and process-swap response time acceptable?

Integrity of the package involves not only function but self-protection. With this in mind, use the following checklist:

1. Does the system incorporate reasonable self-protection mechanisms for stored data and for the program itself?
2. Does data integrity require perfect hardware operation? Is the program tolerant of faults in the processor, disk, telecommunication devices, and operating system?
3. Is "good" data reasonably protected against corruption by unreasonable data?
4. Can questionable data be entered but marked as "not passing edits" or other tests?

Conclusions

One final and valuable lesson from the physical sciences is a recognition of the legitimacy of an experiment that reaches no conclusion, that proves no cherished theory, that uncovers no fundamental truth. It may be unfortunate that no single universal software evaluation formula, no more complex version of the hardware FOM, can be found. Then again, perhaps that is not such a desirable goal after all.

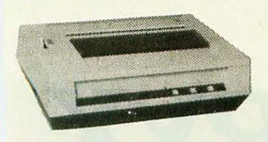
In the end, software performance evaluation comes back to human judgment—to the test pilot, the drama critic, the gourmet, or any individual. The complexity and variety of software packages, the individual tastes and preferences, and the varying modes and environments all come into play to work against easy anwers to the software-evaluation problem. As in life itself, software and its users benefit from the rich diversity, the complex specialization, the adaptability, birth, growth, and death of programs according to the same rules that have led to the existence of the programs' creators. ■

Brian Boyle is managing analyst for the Software Information Service of Gnostic Concepts Inc. (951 Mariner's Island Blvd., Suite 300, San Mateo, CA 94404).

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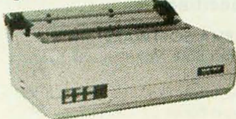
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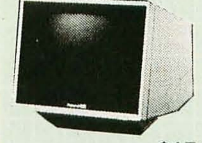
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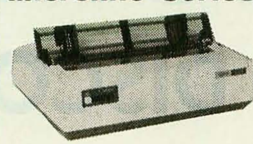
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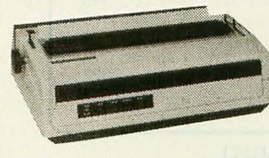


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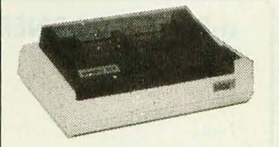


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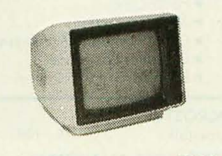
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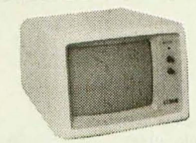
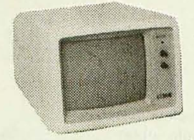
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The Art of Benchmarking Printers

New tests of speed are needed for dot-matrix and daisywheel units

by Sergio Mello-Grand

Developing good benchmarks for computer systems is not an easy task, but benchmarking computer printers is not much simpler. Even if you limit the evaluation to units with list prices under $3000, which excludes the more expensive "page" and "line" printers, the task is still complex because of the great variety of different functions available on today's printers.

Benchmarking efforts can be divided into two principal areas because of the different natures of dot-matrix and fully formed character printers. Dot-matrix types are most popular among personal-computer users and provide an economical and flexible output with reasonable quality. Fully formed character printers, which generally include the more costly and slower units, provide excellent letter-quality output and are popular among companies and professionals who require high quality in their business correspondence. The main distinction is, however, the printing technologies employed; two sets of benchmarks are required.

In this article, I'll document the development of two sets of benchmarks, one set applicable to dot-matrix printers and the other to fully formed character (daisywheel) printers. You'll also find a detailed discussion of the rationale behind each approach and, finally, how several dot-matrix and daisywheel printers performed when subjected to these tests. The actual benchmark listings and test texts are included so you can put your printer through its paces and make some comparisons of your own.

Two sets of benchmarks are required: one for dot-matrix printers and one for daisy wheel printers.

Dot-Matrix Printers

Dot-matrix units employ a printing technique in use for nearly two decades. The printhead has an array of small pins that are independently propelled against an inked ribbon, transferring dots onto the paper behind them. Each pin is activated by an electromagnetic field controlled by the printhead's control electronics. Depending on control codes, one or more pins of the array can be activated at the same time, producing a single dot or a pattern of dots aligned vertically. By moving the printhead horizontally, it is then possible to print a line of characters formed by a controlled pattern of dots.

The basic technology of creating characters through dot patterns is responsible for both the high flexibility and the limited quality of dot-matrix printers. The flexibility stems from the fact that the same array of pins can be used to print any character without waiting for the mechanical rotation of a specific character to a printing position. The reduction in printing quality comes from the discrete nature of the dot *pattern* used to approximate the shape of each character.

Flexibility and quality take on different meanings for each dot-matrix printer. Setting aside each printer's mechanical tolerances in the printhead positioning system (the shaft-to-bearing relation is important because of potentially disturbing vibrations during the head motion), the main element that determines printer flexibility and quality is the pin array.

Older or less expensive dot-matrix *printers* use a seven-pin, one-line array to generate characters from a 5 by 7 dot matrix (each character is a pattern of dots in a cell 5 dots wide and 7 dots high). These units are not very flexible because the combinations of dot patterns available in such a small matrix is very limited. For instance, a 5 by 7 matrix doesn't provide descenders, forcing lowercase letters such as *g, j, p, q,* and *y* into unnatural shapes. Almost all modern dot-matrix printers use a nine-pin in-line array and form characters from a minimum 7 by 9 matrix. This produces true descenders and a closer approximation of traditional characters. Print quality is improved by the denser pattern of dots whose individual boundaries are less visible than those from a 5 by 7 matrix.

The introduction of nine-pin in-line arrays has been a major improvement in dot-matrix printers and has resulted in new capabilities that have greatly expanded their flexibility. For instance, selecting an appropriate pattern, in conjunction with appropriate horizontal stepping, it is now possible to have compressed or emphasized boldface and double-width characters. In the emphasized mode, a printer moves in smaller steps, forming characters out of a horizontally denser matrix (e.g., 18 by 9). In order to achieve even better print quality and compete with the more expensive and slower fully formed character printers, several modern dot-matrix printers also use a double-pass approach or adopt special printheads with nine or eighteen "staggered" pins.

The double-pass approach prints a line in a first pass and, after a tiny vertical shift, reprints the same characters over the same line. This technique provides a near-letter-quality output at the expense of performance. Double-pass printing means at least half-speed printing, an often acceptable compromise when the basic printing speed is 100 cps (characters per second) or more, as in almost every modern dot-matrix printer. Some units also offer a sort of combination of emphasized and double-pass modes that provides a "correspondence" quality in which characters are formed from an 18 by 18 or larger matrix.

To achieve both correspondence quality and high speed, some dot-matrix printers employ printheads with staggered pins capable of printing overlapping dots. The final effect is similar to that achieved with a double pass but without any performance penalty.

Although 9-pin staggered heads have been adopted by some printer manufacturers, better results often are obtained with 18-pin staggered heads. These include two 9-pin arrays located side by side with a half-dot vertical shift. With these heads, the second array's pins hit exactly in the boundary position of the first array's pins. Besides providing correspondence-quality capabilities at full speed, 18-pin staggered heads offer an even higher flexibility in the patterns used for characters.

This brief discussion on the different printheads shows that a comparison among printers based exclusively on speed has limited meaning. To have a more accurate picture of a particular printer's true capabilities, it is necessary to take into consideration some elements of quality. Because a low-quality seven-pin printer has the same speed as a near-letter-quality 18-pin staggered unit doesn't mean that the two printers are comparable from a user's point of view. The first unit might be used only for rough-draft printouts and the second might be used for business correspondence, two activities with very different values for the user.

In designing these benchmarks, I have tried to account for this inequality by including tests for correspondence printouts. You should put equal care into evaluating the results. Remember that any benchmark, no matter how well designed, is only an approximate quantitative comparison that does not take into account very important subjective elements that can be of much greater importance. Furthermore, even the quantitative results are only an approximation, with several limits imposed by some technological restraints.

For instance, I had to face the problem of printers' buffers. Modern printers have an internal buffer that accepts a certain amount of data from the system at high speed, enabling functions such as bidirectional and double-pass printing.

A 128-character buffer may be enough for these functions, *but* several printers offer buffers as large as 48K bytes. Such buffers let a printer store an entire document in its memory, leaving the system free to start a new job while the printer outputs the previous document from its own memory. From the system's point of view, the printer has done its work once it has acquired the whole document in its memory. If you write a benchmarking program using the system's clock, the result for a 48K-byte buffered printer might be astonishing (something in the order of thousands of characters per second).

Without underestimating the importance of huge printer buffers, I have decided to base my measurements on "physical" printing times rather than on "logical" printing times. Such a choice might obviously underrate the real operating performance of a highly buffered printer but is a necessary step in a realistic printer benchmark. After all, several operating systems offer spooling capabilities that provide an almost zero logical printing time, but this doesn't mean that users have no interest in physical printing time.

Another major problem I had to face in these benchmarks is the software support for each printer's control codes. Activating an advanced functionality in a modern printer requires the transmission of one or more control codes to tell the printer's controller that a certain operating mode is to be used. Control codes are needed for underlining, for italics, and for each of the printing modes selectable (emphasized, double-pass, enlarged, compressed, etc.).

Unfortunately, no standard has yet emerged in the chaotic area of dot-matrix printer controllers; each manufacturer uses different codes. With IBM's recent support of certain control codes, a tentative de facto

standard appeared to be emerging, but the industry is still plagued by control-code incompatibilities. From a user's standpoint, this means that a certain software package fully supports some printers and offers only basic functions on other printers. A word-processing program, for example, might take advantage of the immediate underlining capabilities of a popular printer (such as the Epson) and might not take advantage of a similar capability in a different printer because its control codes are incompatible. On the first printer, an underlined line then might be printed at full speed; on the second printer, it might require a continuous output of a character and subsequent over-strike with the underline character. If benchmarked in such an environment, the second printer might very well show a comparatively poor performance even though its intrinsic capabilities are equal to the first one's.

In the absence of a clear industry standard, I didn't want to penalize any printer manufacturer choosing a specific set of control codes, so these benchmarks had to be executable with any unit, no matter how exotic its control codes. As a direct consequence of this choice, I had to give up my original idea of using a popular word processor and a popular spreadsheet for some of the tests. Depending on the program chosen, some printers would have been directly supported and others would not, which is an unjust and discriminatory approach to benchmarking. Word-processing and spreadsheet printout simulations therefore have been conducted directly with some simple BASIC programs that set the appropriate control characters and then print a series of lines of text.

Thanks to the nature of dot-matrix printing, there is no difference in printing one certain sequence of characters and then a different sequence of other characters. This fact lets us use strings of regular characters without having to select a sequence in which the frequency of each different character approximates its frequency in typical English. This is the main issue in benchmarking fully formed character printers. In these benchmarks I have chosen the character *A*, but any other letter will provide similar results.

In designing the following 14 benchmarks, I have tried to utilize the fundamental capabilities of today's dot-matrix printers to evaluate their performance. The advertised printing speeds are generally higher than the measured ones. This depends on the different benchmarking procedures used. Manufacturers measure their units' performances at full speed, without taking into account accelerations and decelerations at the beginning and end of a line. I have viewed performances from the user's perspective, which means that accelerations, decelerations, and even carriage returns and linefeeds have to be considered for a more realistic estimate of a printer's performance.

Bench 1

The first test, which stresses the acceleration/deceleration and linefeed capabilities of a printer, is the output of a single character at the beginning of a line and the repetition of the process on new lines 50 times. Almost all units, even if intelligent and capable of printing in a bidirectional, optimized way, struggle pretty hard in order to minimize the delays connected with the repetitive starts, stops, and linefeeds of this test. This obviously is unfair when measuring performance in terms of the rate of characters per second. Nevertheless, this test shows immediately some sharp behavioral differences among apparently similar printers and can be useful as a first element of comparison.

Bench 2

Extending the Bench 1 test, I print a string of 10 consecutive *A*s at the beginning of a line and repeat the process for 50 lines. In some printers, the time required to complete this test is just a little longer than the time for Bench 1. This shows clearly that, for short lines, the overhead induced by accelerations, decelerations, and linefeeds is much more important than the theoretical printing speed.

Bench 3

As a further extension of the previous tests, I print a string of 20 *A*s at the beginning of a line and repeat the process for 50 lines. This test, besides providing a logical continuity with the two previous ones, is useful in estimating throughput in applications such as label-printing with a single-label horizontal format. BASIC-language listings with short lines are also approximated by this test. As the printers work at full speed in the middle of the string, the cps rating improves, although it is still far from the "official" rates.

Comparing the times for Bench 2 and Bench 3, it's interesting to note that the additional 500 characters involved in the second test require only a few additional seconds to be printed. Dividing 500 by the result of the subtraction between Bench 3's and Bench 2's times, you can obtain a first estimate of the "full-speed" theoretical performance of a printer. In general, this speed is at least equal to the advertised one, which means that the manufacturers are not "cheating." As I have already said, the companies are simply measuring the printing speed in a theoretical way.

Bench 4

I print a string of 40 *A*s and repeat the process the usual 50 times. This text can be used as an approximation for a typical listing. Again, increasing the number of printed characters per line, the measured performance shows a significant improvement, sometimes reaching 70 percent of the advertised speed.

Bench 5

By printing a string of 60 *A*s 50 times on consecutive lines, I am able to approximate a general text printout. The measured performance shows a further increase, with some printers hitting 75 to 80 percent of the rated speed.

Bench 6

Going to 80 characters per line, the maximum line length for the most popular dot-matrix printers (operating at the standard 10 pitch), I print

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50 lines of *As*. Several printers perform at 80 to 85 percent of the official speed, which, after all, is not too bad when you consider that it includes all the necessary starts, stops, and linefeeds. Some printers, though, run at a lower performance ratio, often because their paper-advance motor is not very fast or because they do not provide bidirectional printing.

By comparing the times for Bench 6 and Bench 3 it's possible to get a better estimate of the abstract "full speed" of each unit. This is obtained by dividing 3000 (the number of additional characters) by the result of the subtraction between the times of Bench 6 and Bench 3. As can be seen in table 1, this abstract "full speed" is in most cases even higher than the one claimed by the manufacturers.

Bench 7

After testing the straight printing speed with different length lines, it's interesting to see what happens when a printer operates on formatted text, such as the output of a word-processing program. To emulate this environment, I print 50 times a string composed of 10 blanks followed by 60 *As*. In this way, I can approximate typical letter text with two 10-character margins on both sides.

Intelligent printers, with logic-seeking and look-ahead capabilities, can analyze a buffer's content and optimize the printing path by skipping the leading blanks. Less intelligent units can't do so and will "print" 10 consecutive spaces at the beginning of each line, using a significant (10 to 15 percent) overhead.

As shown in table 1, some intelligent units print the 70-character strings (with 10 leading spaces) of this Bench 7 in the same amount of time required to print the 60-character strings of Bench 5. This confirms that those units recognize leading spaces and optimize their printing paths accordingly.

Bench 8

Stressing even more the logic-seeking capabilities of modern dot-matrix printers, I have designed a benchmark in which a short string of

A Guide to Tables 1 and 4

The numbers in parentheses beneath the printer model numbers indicate the advertised printing speed in characters per second (cps). The numbers in the shaded columns are the times (minutes:seconds) it took the printers to complete specific tests. The numbers in the adjacent, unshaded columns are the approximate printing speeds in characters per second for each test.

	Epson MX-80 (80)		Epson RX-80 (100)		Epson FX-80 (160)		Diablo 11 (100)		Okidata 82A (120)		Okidata 92 (160)		IDS 480 (110)		Gemini 10X (120)	
Bench 1—Print *A* on 50 consecutive lines	00:18	2.8	00:17	2.9	00:13	3.8	00:08	6.2	00:11	4.5	00:16	3.1	00:12	4.2	00:13	3.8
Bench 2—Print a string of 10 *As* on 50 lines	00:23	21.8	00:22	22.7	00:16	31.2	00:13	38.4	00:12	41.7	00:12	41.7	00:16	31.2	00:17	29.4
Bench 3—Print a string of 20 *As* on 50 lines	00:30	33.3	00:27	37.0	00:21	47.6	00:18	55.6	00:16	62.5	00:15	66.7	00:20	50.0	00:22	45.5
Bench 4—Print a string of 40 *As* on 50 lines	00:43	46.6	00:39	51.3	00:29	69.0	00:29	69.0	00:24	83.3	00:21	95.2	00:30	66.7	00:33	60.6
Bench 5—Print a string of 60 *As* on 50 lines	00:55	54.5	00:51	58.8	00:37	81.1	00:40	75.0	00:32	93.8	00:28	107.1	00:39	76.9	00:42	71.4
Bench 6—Print a string of 80 *As* on 50 lines	01:08	58.8	00:62	64.5	00:45	88.9	00:51	78.4	00:40	100.0	00:36	111.1	00:48	83.3	00:52	76.9
Bench 7—*Print a string of* 10 spaces and 60 *As* on 50 lines	00:55	63.6	00:51	68.6	00:37	94.6	00:41	85.4	00:32	109.4	00:28	125	00:39	89.7	00:43	81.4

Table 1: *The results of running the 14 benchmarks for dot-matrix printers on eight members of the dot-matrix family.*

characters (10 *A*s) appears in different positions on five consecutive lines. In the first line, the string is printed in positions 6–15; in the second, in positions 16–25; this continues until the fifth line, in which the string is printed in positions 46–55. In each line, leading and trailing spaces fill the "free" areas from positions 1–60. A loop repeats this sequence 10 times.

A clever unit will print the first string, stopping at position 15, perform a linefeed, and continue printing the second string from positions 16–25. The printer will then perform a new linefeed and start printing the third string from position 26. A similar technique will be used for the fourth and fifth lines. A not-so-intelligent unit, not recognizing the optimized "stair-step" pattern, will instead print some of the blanks. A printer without any logic-seeking capability will print all leading and trailing blanks, with an execution time similar to that of Bench 5.

Bench 9

Another interesting printing example is the simulation of a typical spreadsheet output with a regular table of numbers evenly spaced in rows and columns. To evaluate the printers' behavior in such a case, the benchmark prints a string with an alternate sequence of five spaces and five *1*s 50 times. This process prints a table of 50 rows and 10 columns, each column being 10 characters wide and composed of a five-digit right-aligned number (11111) preceded by five spaces. Intelligent printers with good look-ahead capabilities will recognize each five-space sequence and will skip at high speed to the nearest digit. Intelligent printers without this capability will optimize their path more simply, avoiding the first five spaces of each row. Less intelligent units will print each line just as if it were a regular 80-character sequence.

Bench 10

All the benchmarks described in the preceding pages were conceived for the basic operating mode of 10 characters per inch (cpi) with the standard character set. So far, no compressed, double-width, emphasized, or double-pass operating modes have been considered in the benchmarks. Because they are relevant to some users, I have included five additional benchmarks dealing with these advanced capabilities. Although the modes tested are fairly common, some printers don't support them. For these units, the table of results indicates N/A (not available). In this test, after setting the

Text continued on page 203

Bench 8— Print 10 times 5 strings of 50 spaces and 10 *A*s with different displacement	00:32	93.8	00:32	93.7	00:31	96.8	00:21	142.8	00:26	115.4	00:18	166.7	00:32	93.7	00:36	83.3
Bench 9— Print a string of 8 alternate groups of 5 spaces and 5 *1*s on 50 lines	01:05	61.5	00:60	66.7	00:43	93.0	00:53	75.5	00:39	102.6	00:35	114.3	00:46	87.0	00:51	78.4
Bench 10— Same as Bench 5 but with emphasized mode, i.e., 18 by 9 matrix	01:36	31.2	01:30	33.3	01:01	49.2	N/A		N/A		N/A		N/A		01:09	43.5
Bench 11— Same as Bench 5 but in double-pass mode, i.e., 9 by 18 matrix	02:33	19.6	02:04	24.2	01:47	28.0	N/A		N/A		01:13	41.1	N/A		01:44	28.8
Bench 12— Same as Bench 5 but in correspondence mode	03:53	12.9	03:28	14.4	02:36	19.2	02:35	19.4	N/A		01:52	26.8	00:52	57.7	02:36	19.2
Bench 13— Same as Bench 5 but in compressed mode	01:04	46.9	01:01	49.2	00:44	68.2	00:41	73.2	00:32	93.8	00:29	103.4	00:39	76.9	00:48	62.5
Bench 14— Same as Bench 4 but in double-width mode	01:07	29.9	01:02	32.3	00:41	48.8	00:50	40.0	00:41	73.2	00:37	54.1	00:49	40.8	00:57	35.1

Listing 1: *Dot-matrix printer benchmarks 1 through 9 in BASIC. The text discusses benchmarks 10 through 14, which use benchmarks 4 and 5 in emphasized, double-pass, correspondence-quality, compressed, and double-width modes. Results of these benchmarks on three typical dot-matrix printers are shown in table 1.*

```
10 FOR I=1 TO 50
20 LPRINT "A"
30 NEXT I

10 FOR I=1 TO 50
20 LPRINT "AAAAAAAAAA"
30 NEXT I

10 FOR I=1 TO 50
20 LPRINT "AAAAAAAAAAAAAAAAAAAA"
30 NEXT I

10 FOR I=1 TO 50
20 LPRINT "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"
30 NEXT I

10 FOR I=1 TO 50
20 LPRINT "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"
30 NEXT I

10 FOR I=1 TO 50
20 LPRINT "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAA"
30 NEXT I

10 FOR I=1 TO 50
20 LPRINT "          AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAA"
30 NEXT I

10 FOR I=1 TO 10
20 LPRINT"     AAAAAAAAAA                                              "
30 LPRINT"               AAAAAAAAAA                                    "
40 LPRINT"                         AAAAAAAAAA                          "
50 LPRINT"                                   AAAAAAAAAA                "
60 LPRINT"                                             AAAAAAAAAA      "
70 NEXT I

10 FOR I=1 TO 50
20 LPRINT"     11111     11111     11111     11111     11111     11111
     11111     11111"
30 NEXT I
```


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Text continued from page 199:

printer into emphasized mode, I printed a string of 60 *A*s on 50 consecutive lines, as in Bench 5.

In emphasized mode, the printhead moves in smaller steps, forming a character from a horizontally denser matrix. This produces a better-quality printout but at the expense of speed, as is clearly indicated by the results. This benchmark, when compared to the similarly structured benchmarks that follow for fully formed character printers, gives you a good idea of the comparative performance of a dot-matrix printer operating in "quality" mode and a fully formed character printer operating in its native high-quality mode.

Bench 11

A popular approach used by dot-matrix printers in order to obtain a better output quality is to print a line and, after a very small vertical shift, reprint the same characters on top of it. In this way, characters are printed from a denser matrix, which provides a better quality. In order to test the performance penalty caused by this operating mode, after setting it, I once more printed a string of 60 *A*s on 50 consecutive lines. The benchmark's results show clearly that the throughput is, in general, a little less than half the standard one.

Bench 12

Some printers let the user select an operating mode in which emphasized and double-pass modes are combined to obtain an even denser dot matrix and, consequently, a better correspondence quality. After this mode is set, this benchmark prints the usual string of 60 *A*s on 50 consecutive lines. Suffering from a double overhead, the printers that use this sophisticated operating mode often perform slowly but sometimes compensate with outstanding print quality.

Bench 13

Most printers offer a compressed operating mode that fits 132 characters in an 8-inch line. This operating mode sacrifices part of the quality available in the standard printing mode but shouldn't generate any additional overhead. Bench 13, based on the traditional string of 60 *A*s printed on 50 consecutive lines, confirms that the printing time in compressed mode is often roughly equivalent to the printing time in standard mode.

Bench 14

In order to test the double-width mode, I first activated it with the appropriate control codes and then printed a string of 40 *A*s on 50 consecutive lines, just as I did in Bench 4. As standard double-width characters use a horizontally expanded matrix (double the standard one), 40 characters cover the entire 8-inch width of the standard European paper. The benchmark's results demonstrate that, as expected, the printers' performance is almost half the basic one, estimated by Bench 4.

Other Considerations

Although I have examined and tested several printing possibilities, I haven't covered the broad spectrum of possible applications and operating modes of a modern printer.

Some modes (such as underlining, italics, slanted, etc.) haven't been considered because, generally, they do not involve a performance degradation of a printer. Their expected performance should be similar to the performance measured for the standard operating mode.

Some modes, obtainable through a combination of basic operating modes (such as double-width compressed) offer performances that can be estimated by joining the benchmarks' results for their basic elements. Other modes, such as high-resolution graphics, have not been considered because only a few of today's printers provide good graphics support as standard. Those that do show a large resolution variability that might have penalized the units with densest dot resolution. Today, quality rather than quantity is the most relevant factor in graphics printing. This is probably also true

for correspondence printing and for several basic printing applications. Benchmarking, then, is only a way to acquire more information, not to make direct decisions based on quantitative estimates.

Fully Formed Character Printers

To analyze fully formed character printers, I have to take into account several new factors. These factors are not relevant to benchmarking dot-matrix units but are very important in evaluating the expected throughput of this group of printers.

Nowadays, the most popular type of printer with fully formed characters is the so-called daisywheel printer. This technology is based upon a printhead mechanism in which a small hammer hits a specific petal of a daisywheel. Each one of a typical daisywheel's 96 petals carries a solid font representation of a different character. The character's image is transferred onto the paper after the petal is hit by the hammer, pushing the character outline against the inked ribbon and onto the paper. When a character is to be printed, the daisywheel must be rotated so that the corresponding petal is positioned in front of the hammer. Only at this point can the hammer hit the petal.

Rotation of the daisywheel requires a certain amount of time, correlated with the necessary angle of the rotation. When printing a sequence of the same character (e.g., a sequence of zeros), after an initial setting no additional rotational time is needed. In this case, the printer simply moves the printhead one position horizontally and prints the character without having to wait for any daisywheel rotation. When printing a sequence of different characters, the printer has to wait for the positioning of the appropriate petal in front of the hammer, an activity that is responsible for the slower speed of daisywheel printers.

The need to rotate a mechanical printing element in order to select the character to be printed is common to all the fully formed character printers based on different technologies. These include original teleprinter-type units, the "ball" printers (IBM Selectric types), and the "artichoke" units, like the NEC Spinwriter. Given the existence and importance of this "rotational delay" in all the different types of solid-font printers, the application of benchmark patterns originally developed for matrix printers makes very little sense. Not even an unscrupulous manufacturer of fully formed character printers dares to rate the speed of its units on the basis of repetitive, single-character benchmarks that would dramatically misrepresent their throughput.

Any benchmark of a fully formed character printer has to take into account a pattern of different characters, conceived, if possible, in such a way as to be a good approximation of the real operating environment of the user. Unfortunately, the definition of such a benchmark is not a trivial task. An elementary approach might be to print the whole character set on the daisywheel in order to exercise all the different rotations. Of course, the ordering of the characters in the sequence would deeply influ-

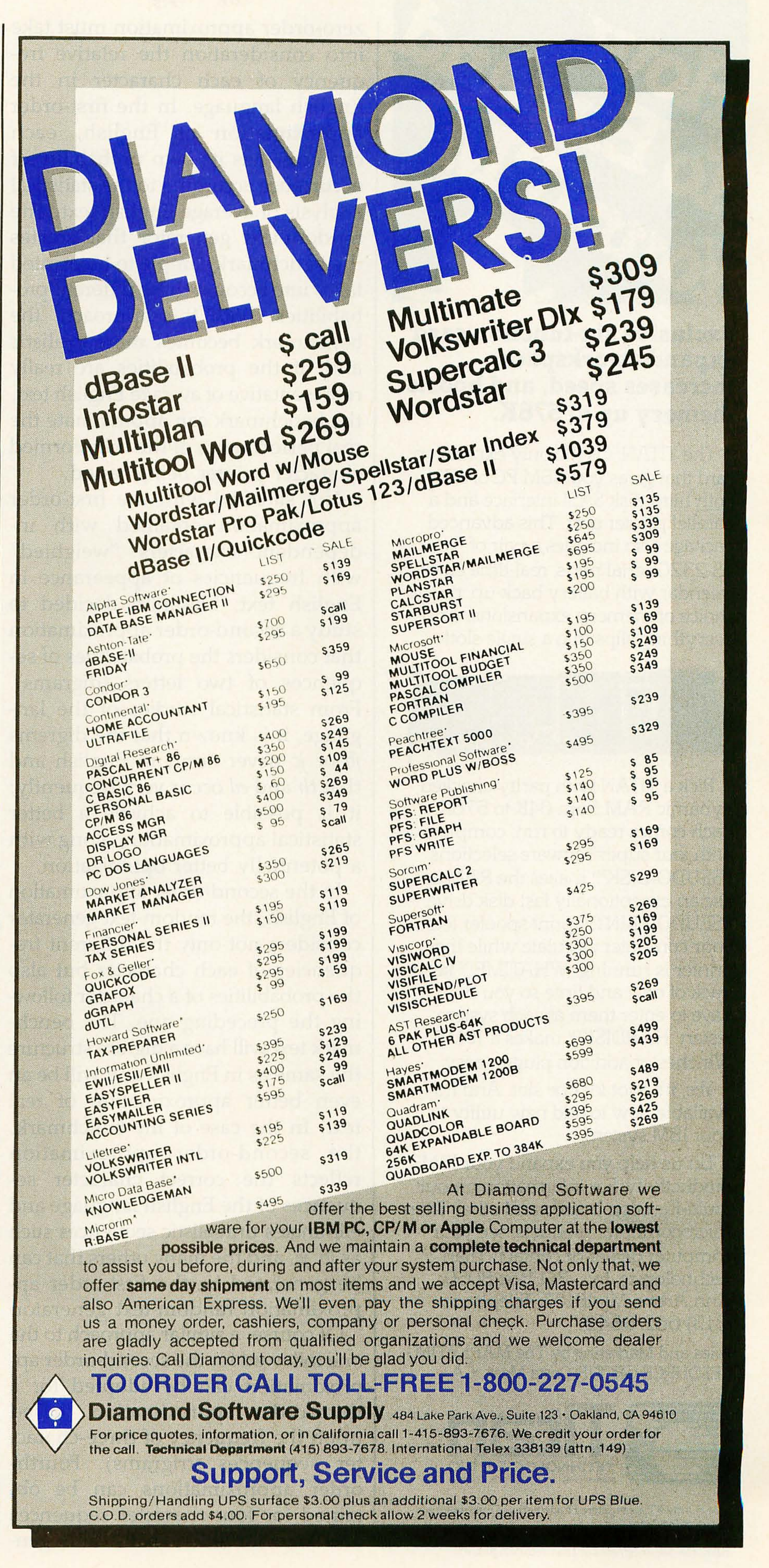
ence the results. To make the test a little more realistic, you might print the characters in a sequence created by a random-number generator with equal probability of occurrence for each character. Claude Shannon, called the father of information science, has termed this approach *zero-order approximation*. In *The Mathematical Theory of Communication*, written with Warren Weaver and first published in 1949, Shannon used the problem of approximating English as an example in his analysis of discrete, noiseless systems.

The problem of optimizing telegraphic transmissions brought Shannon to the more general analysis of statistical properties of English, with results of great relevance to fully formed character printers.

In telegraphy, as well as in printing, the messages to be transmitted or printed consist of sequences of characters. As Shannon notes, "These sequences are not completely random. In general they form sentences and have the statistical structure of, say, English. The letter *e* occurs more frequently than *q* and the sequence *th* more frequently than *xp*, etc." The statistical structure of text has been used to optimize transmission; short symbols replace frequently occurring letters (the letter *e* is a single dot), and longer ones replace infrequently occurring letters (*q*, *x*, and *z* are represented by longer sequences of dots and dashes).

Similar knowledge of the statistical properties of English text has been used with fully formed character printers to optimize the rotational delays of daisywheels and other units with rotating printheads. Because the character *e* is used most frequently in English (after the "space"), it has been placed in a position to result in, on the average, the lowest rotational delay. All other characters have been arranged according to their frequency of use, with a few exceptions related to some physical restraints of the daisywheel. (It is sometimes difficult to fit big characters in adjacent petals without potential mechanical interference.)

With all this in mind, it is apparent that a more realistic test than the



zero-order approximation must take into consideration the relative frequency of each character in the English language. In the first-order approximation of English, each character has its own probability of occurrence according to the statistical analysis of average English text. The random-text generator that creates the benchmark sample to be printed takes into account these different probabilities. With this approach, the benchmark becomes more realistic and, if the probabilities are really representative of average English text, the benchmark can approximate the real performance of the fully formed character printer being tested.

Not satisfied with the first-order approximation obtained with independent characters "weighted" with frequencies of appearance in English text, Shannon decided to study a second-order approximation that considers the probabilities of sequences of two letters (digrams). From statistical studies of the language, it is known that the digrams *jb* or *jc* never occur in English and that *th* and *ed* occur very frequently; it is possible to achieve a better statistical approximation, along with a potentially better optimization.

In the second-order approximation of English, the random-text generator considers not only the different frequencies of each character but also the probabilities of a character following the preceding one. The benchmark text will have a digram structure the same as in English and will be an even better approximation of real text. In the case of my benchmark, the second-order approximation reflects the correct character sequences of the English language and eliminates unrealistic sequences such as *jb, jc,* and the many others that can be generated by the first-order approximation random-text generator.

Of course, a similar approach to the one followed for the second-order approximation can be adopted for a third-order approximation, based upon the frequency of three-character sequences (trigrams). Fourth-order approximations can be obtained for four-character sequences and so on for fifth-, sixth-, and, generally, nth-order approximations. In practice, highly accurate approximation results are almost impossible to obtain due to the exponential growth of the frequency matrixes. A fourth-order correlation matrix for a 96-character set would include 96^4 (84,934,656) elements, each a floating-point number indicating the frequency of a certain tetragram. Obviously, then, even a large number-crunching supercomputer could have trouble with such a huge matrix. Moreover, for the purpose of this article, the improvement in the benchmark's approximation of reality obtained by going to third- and fourth-order approximation would be only minimal. After all, the main concern here is the rotational delay from one character to the following one while maintaining correct frequencies of character occurrence and correct two-character sequences.

Rather than face the huge complexities of fourth-order approximations, Shannon decided to adopt a different approach, leaving the character level and passing to the word level. Instead of approximating an English text with random sequences of characters, he decided to make an approximation with random sequences of English words. Again, you can follow a zero-order approximation approach by choosing random words from a dictionary as if their frequencies were equal. A better approach, though, is a first-order word approximation, in which words are weighed by the random-text generator according to their frequency of occurrence in average English. An even better approach is a second-order word approximation that takes into account the word frequency and the probability of a word to follow another word.

As an example of this second-order approach, Shannon supplies the following nonsense sentence: The head and in frontal attack on an English writer that the character of this point is therefore another method for the letters that the time of whoever told the problem for an unexpected.

This sentence, which Shannon uses as an example of statistical approximation to ordinary English text,

(1a)

```
The head and in frontal attack on an english writer that the character of this
point is therefore another method for the letters that the time of who ever told
the problem for an unexpected. The head and in frontal attack on an english writer
that the character of this point is therefore another method for the letters that
the time of who ever told the problem for an unexpected. The head and in frontal
attack on an english writer that the character of this point is therefore another
method for the letters that the time of who ever told the problem for an unexpected.
```

(1b)

```
The head and in frontal attack on an english writer that the
 character of this point is therefore another method for the
 letters that the time of who ever told the problem for an u
nexpected. The head and in frontal attack on an english writ
er that the character of this point is therefore another met
hod for the letters that the time of who ever told the probl
em for an unexpected. The head and in frontal attack on an e
nglish writer that the character of this point is therefore
another method for the letters that the time of who ever tol
d the problem for an unexpected.
```

Figure 1: *The Shannon test (573 characters) at a width of 80 characters in 1a and 60 characters in 1b.*

has been adopted by almost all manufacturers of fully formed character printers for evaluating the performance of products. Thus, the universally adopted Shannon test for measuring the expected performance of a fully formed character printer is not a test purposefully designed for benchmarking. It is only an adopted test, derived from an example in Shannon's book. When Shannon wrote his book, he had no intention of specifying a printer benchmark for 1980s fully formed character printers.

The main problems with the so-called Shannon average-English test are the incorrect statistical frequencies of characters with respect to average American-English text, and the use of a limited subset of characters. How much this distorts the evaluation of a fully formed character printer's benchmark is hard to say, but it is obvious that the Shannon test is not at all the best possible benchmark for this type of printer.

Before trying to define a better benchmark, however, it's interesting to analyze in more detail the two main limits of the Shannon test. To do so, I considered the version of the test used by Diablo Systems Inc. (see figure 1). By counting the occurrence of each alphabetical character (plus "space") in Shannon's test, I obtained the data shown in table 2, column 3. This frequency data then can be compared with several other frequency data computed by linguistic and behavioral researchers.

Among the many efforts to establish a "definitive" frequency count for words and characters in English, the most comprehensive work is the research done at Brown University and published in 1967 by H. Kucera and W. H. Francis, *Computational Analysis of Present-Day American English.* A huge amount of English text (approximately 1 million words) from a large variety of authors and sources

Character	ASCII Number	Shannon Test	American English Average	First-Order English Test	Fourth-Order Shakespeare Test
space	32	18.421	17.241	16.500	18.205
a	97	6.316	6.300	5.700	7.712
b	98	0.526	1.279	1.600	2.023
c	99	2.105	2.574	1.600	1.517
d	100	2.632	3.274	4.300	3.793
e	101	12.105	10.444	9.300	9.482
f	102	3.158	1.939	2.000	2.528
g	103	0.526	1.618	1.700	1.264
h	104	7.895	4.560	5.000	3.666
i	105	3.684	6.079	6.600	4.425
j	106	0.000	0.132	0.200	0.253
k	107	0.526	0.540	0.700	0.759
l	108	2.632	3.404	3.900	3.413
m	109	1.579	2.108	1.900	4.425
n	110	5.263	5.889	5.500	5.057
o	111	6.842	6.331	7.200	6.700
p	112	1.579	1.682	1.600	1.138
q	113	0.000	0.089	0.100	0.000
r	114	6.842	5.097	4.500	4.172
s	115	2.105	5.380	5.900	6.068
t	116	12.631	7.725	8.600	6.827
u	117	0.526	2.256	1.800	3.287
v	118	0.526	0.827	0.800	0.506
w	119	1.053	1.565	0.900	1.138
x	120	0.526	0.163	0.200	0.126
y	121	0.000	1.424	1.900	1.517
z	122	0.000	0.078	0.000	0.000

Table 2: *A comparison of character frequencies for the four daisywheel-printer tests discussed in the text.*

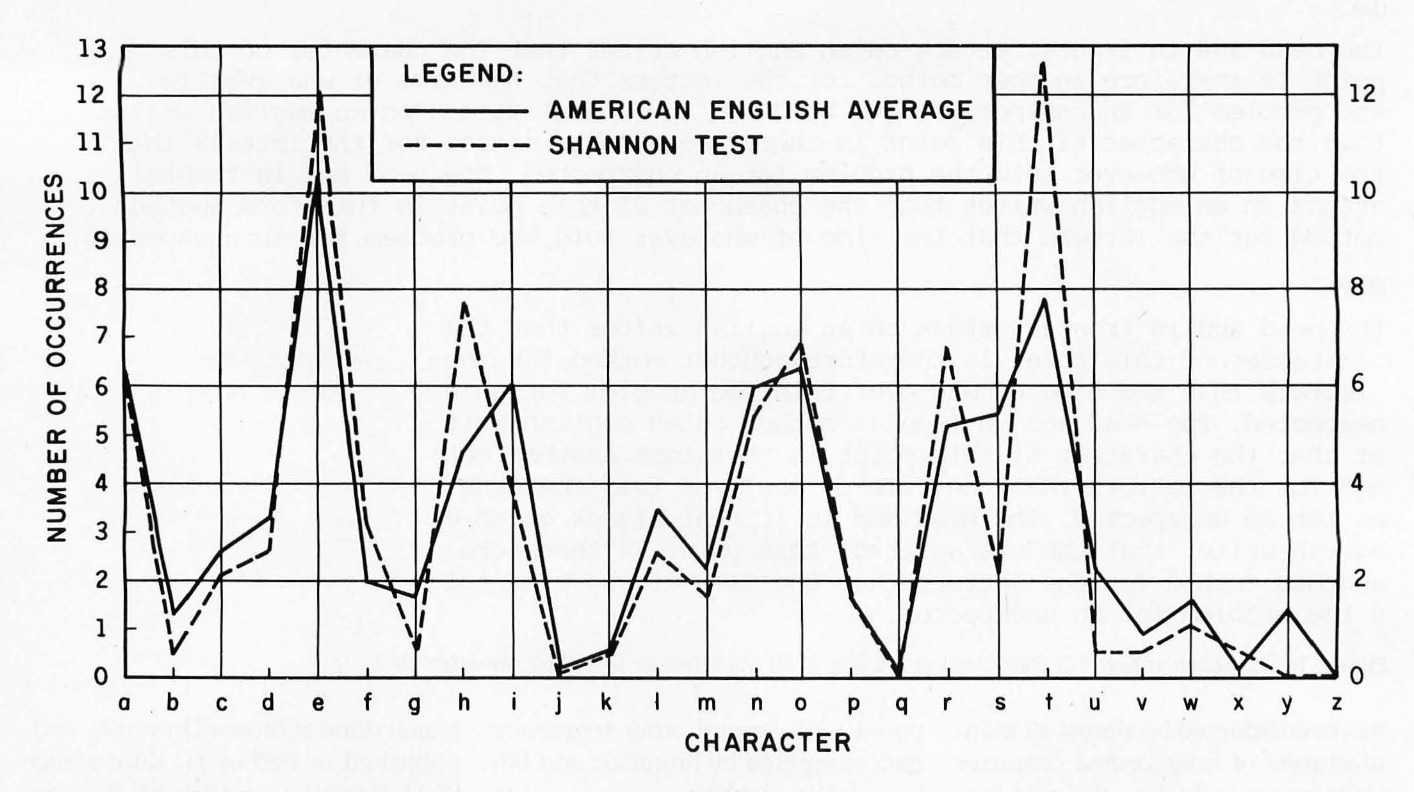


Figure 2: *American English average character frequency compared with the Shannon test.*

(literature, newspapers, etc.) was analyzed and a frequency count made for each of the approximately 40,000 different words.

In 1976, R. Solo and J. King, from the University of Idaho and the University of Chicago, respectively, published a character-oriented frequency analysis based on the word list of Kucera and Francis. Here's an example of the procedure for counting total frequency of characters. The word *note* has a frequency of 127 per million. The frequency totals for the letters *n, o, t,* and *e* are incremented by 127. This procedure was used for each word on the Kucera and Francis list.

Unfortunately, the analysis by Solo and King on character, digram, and trigram frequencies, developed to analyze the structure of words, doesn't take into account the "space," a very important element in a printer's benchmark. This unfortunate omission can be corrected in the table for character frequencies by inserting a mathematically determined space frequency and by recalculating all the other frequencies accordingly.

A correct space frequency for the English language can be computed from the same work by Kucera and Francis that was used by Solo and King for their frequency counts. Dividing the 4,576,585 characters in the sample by its 953,456 words results in an average word length of 4.8 characters, which can also be used as a letter-to-space ratio. Recomputing the Solo and King frequencies and including spaces results in the data shown in column 4 of table 2, which might be considered the best basic frequency count for the purposes of this article. Comparing this data with that calculated from the Shannon test (see figure 2), it's evident that Shannon's sample is not a particularly good approximation of character frequencies in average English text.

Since 1948, when Shannon wrote his book, computers have greatly simplified the statistical analysis and simulation of text, and, taking advantage of such resources, it is certainly possible to define a better benchmark. Following the pattern used by Shannon, it is possible to construct first- , second- , and third-order character approximations based on the work by Solo and King for character, digram, and trigram frequencies and first-order word approximations based on the work on word frequencies by Kucera and Francis.

At this point, with a simple program based on a random generator that considers the different probabilities of each character, it is possible to create a first-order character approximation of English text to be used as an alternative benchmark to Shannon's test. The approximate 1000-character text shown in figure 3 is the result of such a weighted random-text generation and, although it is certainly not a piece of fine literature, it can be used as a first alternative benchmark. Analyzing its character frequencies, reported in column 5 of table 2 and in figure 4, it is apparent that this first-order character text offers a better approximation of average English character frequencies than Shannon's test text.

As previously discussed, second- , third- , and fourth-order character approximations would provide an even better sample text. Unfortunately, digram and trigram counts (tetragrams are not available) from Solo and King do not include spaces and, in this instance, there is no way to recompute relative frequencies as

```
ntor hh uoiweutilnopnhe oif rilpnah h elydnuetrueffoaarootci
h hmaebls    oitmkog esthasls wlnosea edl acitf iehnteagtrdh
 yteolhose feens omnootcsesh eu oha eb c  o mfaes ennynttey
ifl hhbvy hotahltllltt dtnmd  vnsdutisd aegnfiotrcn a spv iy
ei  fethtlngiorrn nept ntk aenaovmhot  enilegeariontessptawo
orf raimrug ome itmbadtt lhadutjhttssdltlanmaoaldiotorpemhti
 o s hiiaossseie ri drcey hidttiedsnerytteli osvioks   a  eh
peap ogbid iw   treaeeis nuc nlgi ntgt oden h oppttnroret n
 rlj pylbnbd ifeesnn ka rnlh rteteivyiyint  i arolato  te  e
a morapsrthennr  hoai nntte irscnegrndid d ocopse s tbd dho
esua  bcii ia talyb seces efe uit ohuorshssosoemlfie msfddco
odtb he sir i tvhihietuihed fx aseer sdec  oo nho ulseosotft
aweybs rt odolif  eeuiih o ger kma bhyothat rlrrklersg rasgi
rdtrpis  dctt a  hnheostsbddalyamtp ntnrn ee hs tnwaed thd l
 u oewgedatelytseh ithhindftex dsss luo pet hal itdhofwabl
uq  l onraes dt t atlon osasa hmrytndntei  gas geciooriiia
koomg fn eoicatiavyeewedry tms nedabeido
```

Figure 3: *American English first-order random approximation (1000 characters).*

I did for single-character counts. Thus, it is not possible to create a second- or third-order character approximation based on their extensive work. Other researchers, working on smaller samples, have fortunately considered spaces in their digram, trigram, and (also) tetragram counts and have been able to create second-, third-, and fourth-order random approximations of English text. Among these researchers is W. R. Bennet Jr., whose work at Yale University resulted in the 1976 publication of *Scientific and Engineering Problem-Solving with the Computer.* In part of this book, Bennet considers the popular idea that enough monkeys, given enough time, could pound away at typewriters and eventually reproduce the great works of literature.

Instead of messing with a multitude of monkeys working at typewriters, Bennet developed a series of simulation programs to do the same job in a much faster and neater way. An early program simulated a monkey working on a traditional typewriter with equal probability for each character (zero-order approximation). Of course, even with the fastest computer, Bennet probably would still be waiting for a barely acceptable piece of literature resulting from this program.

A second program introduced a virtual typewriter with a different probability for each character. For this simulation, Bennet used frequencies from Act III of Shakespeare's *Hamlet,* a 35,224-character text. Even with this approach (as you can imagine looking at our own first-order approximation text in figure 3), Bennet had little hope of obtaining a readable piece of literature, let alone competing with Shakespeare. Using more advanced virtual typewriters, capable of producing second-, third-, and fourth-order approximations, Bennet's "monkeys" showed significant improvements, producing almost intelligible fourth-order text (90 percent of the words appear in an English dictionary).

Thanks to Bennet's research, it is possible to use a fourth-order random (monkey) approximation of Shakespeare's *Hamlet,* which, in turn, is a good example (especially in literary terms) of English prose. Such a simulated text, as published by Bennet, is shown in figure 5. Comparing this text's frequencies with those of Solo and King (see figure 6) reveals a closer similarity than in Shannon's text or in my own first-

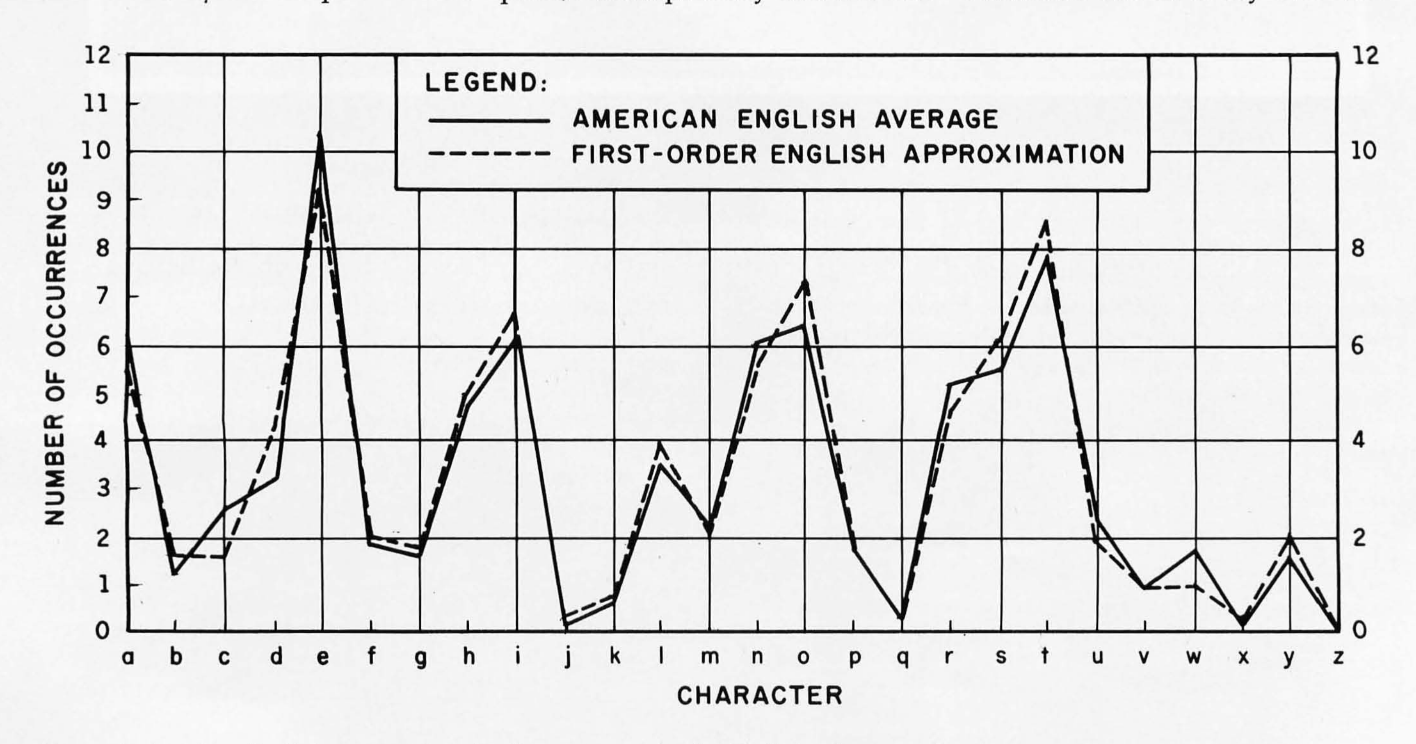


Figure 4: *American English average character frequency compared with first-order approximation.*

order approximation. Consequently, I adopted this text as an additional benchmark for measuring the performance of fully formed character printers.

So far, I have considered only lowercase English text with a character set limited to the 26 basic characters of the alphabet plus the space. But almost any actual text includes uppercase characters, digits, and punctuation marks. Periods, commas, and apostrophes generally have a higher frequency than characters such as *q*, *j*, and *x*. Moreover, in almost all business letters and manuals, for which fully formed character printers are primarily used, digits have an appreciable frequency of appearance.

Unfortunately, even with several visits to computer science, linguistics, and English departments at Stanford and the University of California at Berkeley, I couldn't find a good analysis of character frequencies that included capital letters, punctuation marks, and digits. A long computerized search through the comprehensive Language and Language Behavior Abstracts DataBank didn't solve the problem either. I also struck out with direct inquiries to companies such as Diablo, which probably has this data but considers it proprietary.

```
a go this bare and judgement of timedious retch and not lord
whal if the easelves and do and make and base gathem i ay
beatellous we play means holy fool mour work from inmost
bed be confould have may judgement was it massure's to
lady would hat prime that's our thrown and did wife father'st
livength sleep tith i ambition to thin him and force and law's
may but smell so and spursely signor gent much chief mixturn
ecstance of the me to like crafts did too my mome fair your do
himself it perce as makes so but our heart ourself and be
armont i does unsee a sent statio hamlet the is tongs musince
hyperationse and hamlet heave madamnable must as frank on
hecat now by and stings he's borruptis free our els the speak
it soul o broad fore you as aught of ment ape a broom modestill
be but is man effence are
```

Figure 5: *Fourth-order approximation of Shakespeare's Hamlet (796 characters).*

Because I wanted to have at least one benchmark text with an extended character set, I decided to calculate my own frequencies through a computerized analysis of an English text. For a change, I decided not to use Shakespeare or other classical literature but opted for a different kind of text: the on-line Unix manuals. This choice means that the sample benchmark I eventually obtained is not an approximation of average English but an approximation of some technical computer literature; frequencies are skewed due to computer-jargon characters. Speaking of Unix, the frequencies of slashes and backslashes are much higher than in an average English text. Nevertheless, because a lot of fully formed character printers are used to print computer-related manuals, reports, and articles, a benchmark approximating this environment might be appropriate and interesting.

In order to build a representative frequency table for the potential 256 ASCII (American National Standard Code for Information Interchange) characters, I have analyzed (using a PDP-11/70) a sequence of over 1½ million characters from the Unix online manuals. The results from this analysis are shown in table 3, which lists the frequencies for the 96 ASCII characters (codes 32 to 127) relevant for fully formed character printers. These frequencies have been recalculated from the raw Unix analysis

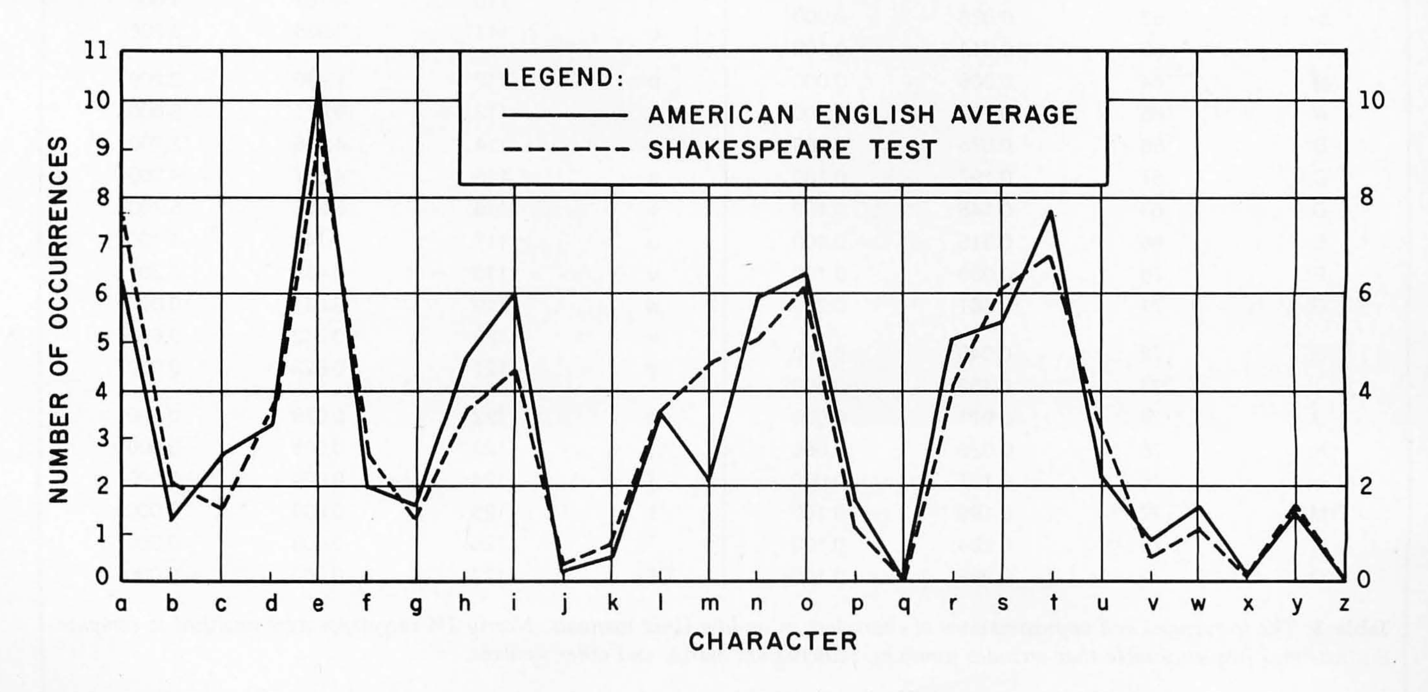


Figure 6: *American English average character frequency compared with fourth-order Shakespeare approximation.*

Character	ASCII Number	Frequency	Approximation	Character	ASCII Number	Frequency	Approximation
space	32	29.694	28.300	P	80	0.313	0.100
!	33	0.011	0.000	Q	81	0.007	0.000
"	34	0.104	0.100	R	82	0.151	0.200
#	35	0.016	0.000	S	83	0.448	0.300
$	36	0.019	0.000	T	84	0.397	1.000
%	37	0.032	0.000	U	85	0.156	0.100
&	38	0.007	0.000	V	86	0.022	0.000
'	39	0.243	0.400	W	87	0.041	0.000
(	40	0.441	0.800	X	88	0.092	0.000
)	41	0.445	0.100	Y	89	0.055	0.000
*	42	0.065	0.100	Z	90	0.016	0.000
+	43	0.026	0.000		91	0.073	0.000
,	44	0.554	0.800	\	92	0.017	0.000
-	45	0.463	0.500	]	93	0.072	0.000
.	46	0.975	1.300	^	94	0.008	0.000
/	47	0.463	0.600	_	95	2.164	2.200
0	48	0.191	0.200	`	96	0.126	0.100
1	49	0.490	0.400	a	97	4.350	*4.500*
2	50	0.211	0.300	b	98	0.916	0.900
3	51	0.082	0.000	c	99	2.067	2.200
4	52	0.069	0.100	d	100	2.238	1.800
5	53	0.092	0.100	e	101	7.681	9.400
6	54	0.038	0.000	f	102	1.587	1.000
7	55	0.048	0.000	g	103	1.061	1.500
8	56	0.109	0.100	h	104	2.198	2.000
9	57	0.027	0.000	i	105	4.251	4.100
:	58	0.073	0.000	j	106	0.044	0.000
;	59	0.110	0.100	k	107	0.290	0.200
<	60	0.025	0.000	l	108	2.589	2.800
=	61	0.033	0.000	m	109	1.817	2.000
>	62	0.028	0.000	n	110	4.153	4.600
?	63	0.014	0.100	o	111	3.935	3.200
@	64	0.006	0.000	p	112	1.496	2.200
A	65	0.233	0.300	q	113	0.071	0.000
B	66	0.075	0.000	r	114	4.006	3.700
C	67	0.197	0.100	s	115	4.057	4.300
D	68	0.146	0.100	t	116	5.286	5.700
E	69	0.315	0.000	u	117	1.742	1.100
F	70	0.080	0.100	v	118	0.439	0.300
G	71	0.061	0.200	w	119	0.661	0.800
H	72	0.046	0.100	x	120	0.272	0.600
I	73	0.452	0.500	y	121	0.823	0.900
J	74	0.011	0.000	z	122	0.073	0.100
K	75	0.023	0.000	{	123	0.009	0.000
L	76	0.127	0.000	|	124	0.024	0.000
M	77	0.199	0.100	}	125	0.009	0.000
N	78	0.284	0.100	~	126	0.009	0.000
O	79	0.229	0.100	DEL	127	0.000	0.000

Table 3: *The frequencies and approximations of characters in on-line Unix manuals. Nearly 1½ megabytes were analyzed to compute this extended frequency table that includes numbers, punctuation marks, and other symbols.*

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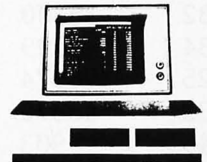
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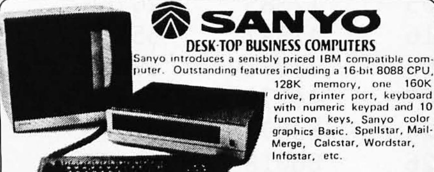
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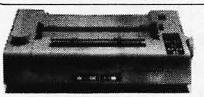
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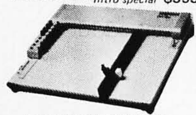


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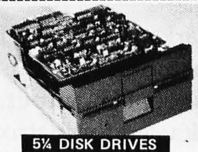
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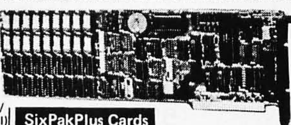
Tandon TM-100-1 Single-sided, double density, 160K formatted. . . $159
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w/either parallel or serial port No. 2	$274	$314	$364	$414	$464
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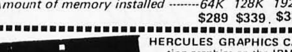
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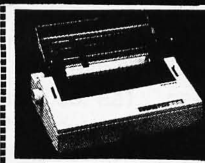
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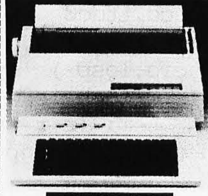


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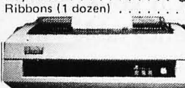
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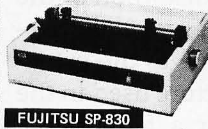


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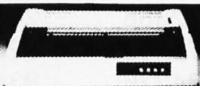
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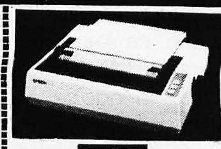
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Tractor for 6100 . . . . $120



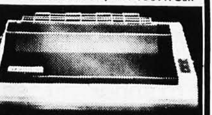
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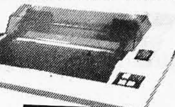
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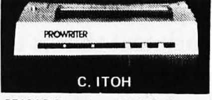


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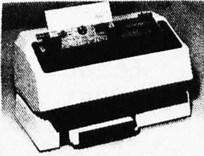
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8023A, 100 CPS, 80 col., par.. $385



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ML-82A, 120 CPS, 80 col, pin & friction feed, serial & parallel $359
Okigraph-I 82A, 60x66 DPI dot addressable gaphics for 82A . . $45
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ML-84P, 200 CPS, 136 col., friction & tractor feed, (parallel) . . . $989
ML-84S, above but serial . . $1,059
ML-92P, 160 CPS, 80 col., friction & tractor feed, (parallel) . . . $459
ML-92S, above but serial . . . $599
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isno ca tleu-tteeilnia/ nea ndeni b c Gex itPsot._an  nkmt e
c cg . ep    metgema lrta per veglrS  A e   es_ eDcitI aso c
 xr_mfamr? _/_hp lghmlr rTrb Tt lb  l      i fa Hr Thiyits-y
eae ca ux alt aesefess  sig   uip tter'  Taiaektn i   rnu ey
_e  aTscteiadlnoh i*ns gse  Ti mugans  4hee_a_ nelht;rons wn
lo_ n egota lf/ esg  (ss ec (tseattrr ete ig m e(elslon2fbte
 i o aee lrrr,e. oe 'n -w bd tte_(ri.nxst0ee lpudlep      ,c
n5 n na e  ew   soA TRer it  iead isas n _i a lnntsiomo.t h
 oee nye i   ea.lrhg e  oheb nt/t.euxeydht  e  ole rm  tl  T
  fin nrota.hin  bn e hhtt- eor iMang d(   i lnpI r s    ai
Irt     de e  s ew  p, /o __R tes lbtlnpappmrlSgeae. fp_(' m
m s  a0 reo d tucecd,ttdc0  _w  pT/n p 2   ni iai tepSlpntas
 vIw p os m nee_  U.tdea l a,o eg   cxntb t oeooee2npa o pae
n(snner  ( ss    cic,losp )  ey fsn htioh _- cr rhu ." sc  e
 t mFva.  t_eytrIc etcceh _s8w  rpr etm nNt c e dt ai_u  e
tn  e lho Cr  s s  semi lr r  afoyti hsTd  a r a. emioddd
eimfa `i _me  sd uyG,wA oz sgp h,'  _e l
```

Figure 7: *First-order Unix on-line manual approximation (1000 characters).*

after removing all control characters and marks below ASCII code 32.

From this new frequency table I implemented a random-text generator to produce a 1000-character benchmark text that is a first-order approximation of the Unix-English language in the on-line Unix manuals (see figure 7). The main distortion of the sample is shown by the very high frequency of spaces, due to the extensive formatting structure used in the manuals. Except for a few special Unix characters, the relative frequencies of the other characters are generally similar to those from the Solo and King analysis (once the higher frequency of spaces is accounted for). On the whole, the approximated Unix-English text, which includes digits, punctuation marks, and uppercase characters, is a different and interesting benchmark, capable of testing the whole rotational spectrum of a fully formed character printhead.

The final benchmark sample that I felt should be included in this analysis is a spreadsheet-like output. As in the benchmark used for matrix printers, I have used a table of 20 rows of eight numbers each. Each row is divided into eight columns of 10 characters each (including spaces). Each cell of the hypothetical spreadsheet output includes a randomly generated integer number in the 0–100,000 range. This benchmark gives us a good idea of numerical output performance and of a printer's space-skipping capabilities. A sample run is shown in figure 8. Table 4 shows the results of running these fully formed character printer benchmarks on two daisywheel printers.

Conclusion

Printer benchmarking first must be divided according to the printing technology employed. Then, appropriate tests must be developed to simulate the activities for which the printer was designed. For dot-matrix types, printing speed, intelligence, and printing modes should be examined. Character sequence has little or no effect on speed in this type of printer. Daisywheel printers need carefully designed benchmarks that approximate the occurrence frequency of native (in this case, English) language characters because printwheel rotation limits performance.■

Sergio Mello-Grand (1143 Quince Ave., Sunnyvale, CA 94087) is the U.S. editor for the Italian technical magazines Informatica Oggi *and* Bit.

65186	86886	72976	79885	7370	49031	45452	10725
95051	70387	53186	97116	32093	95613	93451	53494
56442	67122	70257	74077	66688	45394	33414	15685
73627	54288	42597	5545	76827	51354	56405	74106
66186	23145	46426	12856	48497	5532	36300	57126
99011	29015	65778	93911	37997	89034	79789	94676
32307	41284	42499	73174	21938	22025	76374	68251
71593	93397	26246	51668	47245	13732	48370	60907
17698	32866	24490	56984	81152	12449	903	7263
16765	71262	52515	93270	61210	55527	71912	43501
10248	34220	83417	91239	45280	19383	82151	57365
84916	11437	98103	58168	61535	69495	85183	38162
22848	6673	35294	27894	58461	10405	17385	26760
51437	87751	41523	10817	54858	35716	47947	65592
93389	36555	21137	43900	89837	78093	28871	48652
16720	99033	86292	40669	72822	59267	44970	71495
84761	35193	6961	41211	33548	40026	63873	81243
6154	69109	60926	62177	72066	70226	86018	26575
84855	38915	83783	46780	8735	38782	94658	7736
70130	46809	18940	14795	34231	23672	5856	26533

Figure 8: *A spreadsheet simulation featuring eight columns of five-digit random numbers with filling blanks (1600 characters).*

	Diablo 630 (31.8)		NEC 7710 (55)		NEC 3510 (35)		Transtar 140 (40)		Brother HR-25 (13)		Brother HR-15 (23)		Olivetti Praxis 41	
Shannon Test (80 characters wide), 573 characters plus CR/LF	00:15	38.2	00:13	44.1	00:20	28.6	00:17	33.7	00:28	20.5	00:44	13.0	01:24	6.8
Shannon Test (60 characters wide), 573 characters plus CR/LF	00:16	35.8	00:13	44.1	00:20	28.6	00:18	31.8	00:29	19.8	00:45	12.7	01:25	6.7
First-Order English Random Approximation (60 characters wide), 1000 characters plus CR/LF	00:28	35.7	00:24	41.7	00:35	28.6	00:31	32.3	00:50	20.0	01:18	12.8	02:30	6.7
Fourth-Order Shakespeare Random Approximation (60 characters wide), 796 characters plus CR/LF	00:23	34.6	00:19	41.9	00:29	27.4	00:25	31.8	00:41	19.4	01:03	12.6	01:58	6.7
First-Order Unix On-Line Manual Random Approximation (60 characters wide), 1000 plus CR/LF	00:31	32.3	00:24	41.7	00:37	27.0	00:31	32.3	00:52	19.2	01:16	13.2	02:28	6.8
Spreadsheet Simulation (20 rows of eight 10-character columns with five-digit random numbers and spaces), 1600 characters plus CR/LF	00:29	55.2	00:27	59.3	00:38	42.1	00:39	41.0	01:30	17.8	01:33	17.2	03:22	7.9

Table 4: *A comparison of seven daisywheel printers using the benchmark tests discussed in the text. CR/LF, in the first column, means "carriage return and linefeed."*



DIGITAL RESEARCH
WORDSTAR
with SpeedStart
MicroPro
SuperCalc2
with SpeedStart
SORCIM
MicroPlan
with SpeedStart
Chang Labs
GraphPlan
with SpeedStart
Chang Labs
TARGET
Financial Modeling
with SpeedStart
COMSHARE
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SELECT Information Systems
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Benchmarking FORTRAN Compilers

Insights into comparing FORTRAN compilers

by Avram Tetewsky

FORTRAN, or FORmula TRANslation, is a high-level programming language. This means it is "easy to use" or "designed for people," in contrast with low-level machine language, which is difficult to use. Unfortunately, computers don't understand FORTRAN—they understand only machine language. To convert FORTRAN to machine language, we use a FORTRAN compiler.

FORTRAN was designed to be easier to use than machine language, but it was also designed to make scientific formulas easy to program. However, because scientific formulas can be long, FORTRAN programs also need to be fast. Otherwise, a weather-forecasting program might take 20 hours to come up with a forecast you need in 10 hours.

This is where benchmark testing of FORTRAN compilers can be useful, because a benchmark can tell you which compiler creates the fastest code. In a compiler benchmark test, you present the same FORTRAN program—the benchmark—to several compilers, compile the program, and run the resulting machine code from each compiler. The compiler that generates the fastest-running machine-code version of the benchmark is the winner. Some classic benchmark programs are the Sieve of Eratosthenes (a method of finding prime numbers) and Whetstone (a mix of different arithmetic computations originally done in the ALGOL computer language).

However, these benchmarks have a shortcoming in that they use only *local* data, that is, small amounts of data located in one area of memory. I believe that, to be fair, a benchmark should also test how efficiently a compiled program deals with large amounts of data located in all areas of memory. After all, compilers may have different ways of managing large amounts of memory; some ways may be more efficient than others. Finding out which way is better can be very important if you intend to use your FORTRAN compiler on programs that use a lot of data.

Another shortcoming of the classic benchmarks is that they do not test the compile and link times of a compiler. In other words, while the classic benchmarks do tell you how fast the compiled program runs, they do not tell you how long it took the compiler to generate the compiled program. Without this information, you may discover that your superfast code takes a superlong time to compile.

Finally, the classic benchmarks do not measure how well compilers handle I/O (input/output) and array-subscript operations. If they performed this measurement, you would know how well a compiler handles programs that have many I/O statements and matrix operations.

To test how well a FORTRAN compiler manages large amounts of data from all over memory (called *global* data), how fast it compiles, and how fast the compiled code runs, I decided to write my own benchmarks, the results of which are presented in this article. I would have included the listings of the benchmark programs, too, but they are longer than this article and there is no room for them. Also, I could not benchmark complete I/O and matrix operations

Compiler	Disk Space (bytes)	Library Space on Disk (bytes)	RAM Space* (bytes)
Microsoft FORTRAN and LINK-80	40K	30K	48K
Supersoft FORTRAN-66 and LINK-V2	89K	117K	128K
Microsoft FORTRAN-77 and LINK-V2	240K	124K	128K
DEC FORTRAN-77 for VAX 11/780	208K	1460K	V 500K
IBM VS FORTRAN-77 for MVS 370 operating system and LINKEDIT	818K	924K	V 2048K

*Not including operating-system space; V indicates virtual

Table 1: *Disk and RAM requirements for FORTRAN compilers. For the mainframe systems, specifying RAM size is difficult because of the virtual-memory capabilities of the mainframe. (Virtual-memory capability allows a computer to run programs larger than its physical memory can hold.)*

Compiler	Setting	Comments and Setting Definitions
Microsoft FORTRAN	None	INTEGER*2 defaults
Microsoft FORTRAN-77		Always optimizes
	$STORAGE:4	INTEGER*4 by default
	$NODEBUG	No subscript checking
	$NOFLOATCALLS	This gives fastest 8087 support
	CALL MBPRQQ	Treat R*4 and R*8 as declared
Supersoft FORTRAN-66		Defaults to INTEGER*2
		There is no INTEGER*4
	CALL SUBOF%	No subscript checking
DEC VAX FORTRAN-77	FORTRAN/nodebug/ optimize/no check	
IBM VS FORTRAN-77	Optimization = 2	Choose this setting for reliability

Table 2: *Compiler option settings.*

because of a lack of time.

You'll notice that I benchmarked mainframe as well as microcomputer compilers. I did this to give you an idea of how closely microcomputer-compiler systems are approaching mainframe-compiler systems in terms of execution speed.

Besides benchmarking, another way to compare compilers is by the amount of disk and RAM (random-access read/write memory) space that they need. For your convenience, table 1 lists the amount of disk and RAM storage space that each compiler needs. This is essential information to have when you read the benchmarks because you may find that the compiler that did so well in the benchmarks won't fit in your computer.

All the benchmarks in the world won't mean a thing if your compiler does not compile standard FORTRAN. The two standard versions are FORTRAN-66 and FORTRAN-77. The numbers stand for 1966 and 1977, the years in which FORTRAN was standardized by ANSI (American National Standards Institute). For a sizable fee, the National Bureau of Standards Software Test Center (5203 Leesburg Pike, Suite 1100, Falls Church, VA 22041) will test a compiler to ensure that it meets ANSI specifications. Among microcomputer software companies, only Digital Research has decided to brave this test; most mainframe compilers are already certified. If Digital Research's compiler (which is not yet available) passes the test, it will be a virtual guarantee that its compiler will run most existing standard FORTRAN code. None of the microcomputer compilers I benchmarked have been tested by the National Bureau of Standards, but they have been tested by the marketplace, so you can be reasonably sure that they are all pretty much standard FORTRAN.

To Be Fair ...

So many variables are in the typical hardware-compiler system that it's difficult to make a fair comparison. For instance, when you compare a compiler that runs on the IBM Personal Computer with one that runs on an Otrona Attache, you are comparing more than the compilers—you are comparing the computers, too. To be as fair as possible in my benchmark comparisons and be sure that I'm comparing oranges to oranges, I've tried to set as many variables as possible the same way from compiler to compiler. For instance, each compiler has a variety of switch settings that disable or enable options such as optimization, subscript checking, and default storage. I used the settings shown in table 2.

When I measured execution times, I was careful to separate operating-system and I/O-dependent overhead from the results. For example, most mainframe systems are multitasking, so that the computer sandwiches in your program with several others. If you used a stopwatch to measure the time it took the mainframe computer to run your program, you would actually be measuring the time the computer took to run your program, several other programs, and the operating-system program that keeps the whole mess straight.

To accurately measure the execution time of my mainframe benchmarks, I used job-step time, which includes only a small amount of operating-system time. In addition, I performed the tests at 6:00 a.m. to increase the likelihood that no other tasks would be running on the computer. I also set up the measurements so that I/O to the terminal was excluded. For example, it took my DEC

Type of Data	Type of Computation	Computation Time in Microseconds Microsoft FORTRAN 4.77 MHz 8088 & 8087	8.0 MHz 8086 & 8087	DEC VAX FORTRAN	IBM 3081D FORTRAN
local	addition	28.5	17.0	0.3	0.18
global	addition	44.5	26.5	1.3	0.57
local	subtraction	30.2	18.0	0.8	0.26
global	subtraction	45.3	27.0	1.8	0.58
local	multiplication	31.9	19.0	0.5	0.36
global	multiplication	46.1	27.5	2.8	0.66
local	division	53.7	32.0	5.1	0.84
global	division	68.0	40.5	5.9	1.04
local	cosine	721	430.0	96.31	6.51
global	cosine	758	452.0	103.8	6.83
local	arc cosine	551	329.0	94.6	11.01
global	arc cosine	588	351.0	98.31	11.40
local	arc tangent	278	166.5	31.4	4.99
global	arc tangent	317	189.0	33.5	5.48
local	exponential	499	298.0	48.9	8.98
global	exponential	536	320.0	52.9	9.31
local	natural log.	467	279.0	45.7	7.77
global	natural log.	506	302.5	49.4	8.36
local	square root	138	82.5	36.7	6.34
global	square root	176	105.5	49.6	7.09

Table 3: *Single-precision computation speed with local and global data (global data is labeled COMMON in FORTRAN).*

Listing 1: *The Timer routine for Microsoft FORTRAN version 3.1.*

```
EXTERNAL   TICKERS
INTEGER*4  ITIME1, ITIME2, CENTI

CALL TICKER(ITIME1)
....
CALL TICKER(ITIME2)
CENTI  = ITIME2 - ITIME1

; TICKER BY W. CLAFF FOR MICROSOFT FORTRAN V3.1
; CONTACT THE BOSTON COMPUTER SOCIETY
; ONE CENTER PLAZA BOSTON MASS 02108
; IBM-SCIENCE SUBGROUP FOR MORE INFORMATION
; EXTRACT TIME FROM DOS
; CONVERT BCD TIME FROM DOS TO CENTISECONDS
TICKERS   SEGMENT  'CODE'
PUBLIC    TICKER
TICKER    PROC     FAR
          PUSH     BP
          MOV      BP,SP
          PUSH     AX
          PUSH     BX
          PUSH     CX
          PUSH     DX
          MOV      AH, 02CH
          INT      021H
          XCHG     CX,DX
          MOV      AL, CH
          MOV      BL, 100
          MUL      BL
          MOV      CH, 0
          ADD      CX, AX
          MOV      AL, DH
          MOV      BL, 60
          MUL      BL
          MOV      DH, 0
          ADD      AX, DX
          MOV      DX, 0
          MOV      BX, 6000
          MUL      BX
          ADD      CX, AX
          ADC      DX, 0
          LES      BX, DWORD  PTR 6[BP]
          MOV      ES:[BX],CX
          MOV      ES:[BX+2],DX
          POP      DX
          POP      CX
          POP      BX
          POP      AX
          POP      BP
          RET      4
TICKER    ENDP
TICKERS   ENDS
          END
```

(Digital Equipment Corporation) VAX computer 3 seconds to perform a benchmark and an additional 3 seconds to update the terminal with the results. If I hadn't taken steps to separate the terminal I/O time from the true results, I would have come up with a misleading benchmark time of 6 seconds.

With microcomputer benchmarks, most of the results can be obtained with a stopwatch. You can also check the time automatically with the Supersoft compiler's timer call if you are using the Supersoft compiler or with the Timer routine in listing 1 if you are using the Microsoft compiler. (W. Claff, the author of Timer, notes that some systems are more accurate than others. For example, an IBM PC with or without a Quadboard is accurate to only 0.05 second, while a Seattle Gazelle is accurate to 0.01 second.) The only benchmark that is best timed with a software timer is the global- versus local-data benchmark. This is because of the short times involved.

I usually did not include the time to load information from the microcomputer's disks when I measured compiling and linking time. Even when I did include the loading time, it made little difference because microcomputer compile and link times are relatively long compared to disk-load times. I attempted to have scratch files on one drive and the source on the other to minimize disk-drive head-movement times.

You may notice in the benchmark results that I mention an 8-MHz 8087 arithmetic processor chip. Although this item is not yet available, it soon will be. To calculate the effect of an arithmetic coprocessor, I took the factual increase in compiler speeds that such a coprocessor affords at 4- and 6-MHz clock speeds and extrapolated the increase to 8 MHz.

Benchmark Results

Tables 3 and 4 show the differences in computation speed when data is local or global. To get a good feel for the difference, I used many different types of algebraic and trigonometric computations with both single- and double-precision numbers.

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Type of Data	Type of Computation	Computation Time in Microseconds Microsoft FORTRAN 4.77 MHz 8088 & 8087	8.0 MHz 8086 & 8087	DEC VAX FORTRAN	IBM 3081D FORTRAN
local	addition	31.0	18.5	2.4	0.16
global	addition	46.2	27.5	4.7	0.47
local	subtraction	31.9	19.0	2.5	0.28
global	subtraction	46.1	27.5	5.0	0.34
local	multiplication	33.5	20.0	5.5	0.53
global	multiplication	47.8	28.5	6.6	0.70
local	division	55.3	33.0	8.9	1.20
global	division	69.6	41.5	11.3	1.49
local	cosine	736	439	231	9.26
global	cosine	766	457	234	9.90
local	arc cosine	581	347	148	16.90
global	arc cosine	612	365	150	17.37
local	arc tangent	303	181	52.7	5.91
global	arc tangent	332	198	55.7	6.32
local	exponential	525	313	90.9	10.63
global	exponential	555	331	94.1	11.26
local	natural log.	494	295	86.4	11.45
global	natural log.	523	312	98.3	11.90
local	square root	152	91	49.0	8.70
global	square root	183	109	54.0	9.23
average increase in time due to use of global data		22.6	13.5	3.7	0.38

Table 4: *Double-precision computation speed with local and global data.*

Notice that the microcomputer compiler is much slower than the mainframe compilers. Also, on all machines global data does indeed take longer to process. But the most important point of this table is how *much* longer one compiler takes to process global data than another compiler. The average increase in computing time due to global data is shown at the bottom of the table. There, you see that the IBM 3081D computer and its FORTRAN compiler take the least additional time to handle global data.

Table 5 shows the results of the compile- and link-timing tests. I also listed the sizes of the compiled code for the smallest FORTRAN benchmark program that I could write. The benchmark program I used just adds two floating-point numbers together and uses a formatted WRITE statement to send the output to the screen.

What Your Benchmark Will Never Tell You

You can't depend on benchmarks to make your mind up for you because some things can't be benchmarked, such as ease of use and suitability. During my testing of FORTRAN compilers, I formed some opinions and made some observations.

Microsoft FORTRAN, Version 3.44 for CP/M-80 Systems

*Despite an error in format-repetition factors, lack of complex variables, and no backspacing on sequential data files, this is a solid product. While it does have INTEGER*4 variables, it does not allow for INTEGER*4 do-loop control. In addition, you must follow a rigid ordering of statements, the worst being that all declarations must appear before the COMMON statements. Finally, you are limited to 64K bytes minus the CP/M operating-system data plus code. Unfortunately, LINK-80 steals 13K bytes of this space.*

On the plus side, it has a fast compile and link time, requires only a small amount of disk space, and, with the addition of Phoenix's PLINK-II, an overlay linker, you can build some extremely sophisticated programs. Alas, Microsoft no longer updates FORTRAN.

Microsoft FORTRAN-77 ANSI Subset, Version 3.1 for MS-DOS

This compiler, after several miserable releases, works well. The manual is of high quality, the code it produces is very fast, and the price is right at $350.

The major shortcoming is that this two-pass compiler produces scratch files that are about two to three times larger than the input source file. Besides taking a long time to compile, dual 350K-byte floppy-disk drives are inadequate for large programs. High-performance machines such as the IBM PC XT, Seattle Gazelle (hard-disk or 8-inch drives), or an Otrona 8:16 with 96-TPI drives might be a better choice. For PC owners, a 320K-byte drive C: (RAM) disk would also work (power supply permitting).

Finally, the restriction that no array can be larger than 64K bytes, and that multiple large arrays must be in separate labeled COMMON blocks, still prevents one from running some mainframe programs. Microsoft is working on new versions that will ease this restriction and also support the COMPLEX variable type.

Supersoft FORTRAN-66, Version 1.07 for MS-DOS

The main virtue of this compiler is that it can be used on a dual 350K-byte floppy-disk system. While it has many nice extensions to the FORTRAN-66 language, too many of them are nonstandard. Supersoft has fixed many of the problems in version 2.1, now in beta test. In addition, IBM PC graphics will be supported, and a rewrite of the manual is promised.

*Supersoft FORTRAN limits programs to 64K bytes of data and 64K bytes of code. Although this compiler has COMPLEX variables, it lacks INTEGER*4 variables. In an attempt to ensure that only the subroutines used by a program would be included in the executable file, Supersoft made the poor design decision to automatically break up object modules into separate files for each subroutine. This creates a mess at link time.*

Digital Research FORTRAN-77, for CP/M-86 and MS-DOS

This will be available early in 1984. While I have received the manuals (they are excellent), I can only relay the company answers to my questions at this time.

This is a full ANSI-77 FORTRAN with 8087 support. Large memory models are included. The total number of elements in any one array can't exceed 64K bytes. In addition, DRI claims that the scratch files are ⅓ to ½ of the input source file size, so a dual 350K-byte system should be adequate. DRI FORTRAN programs can also call routines written in DRI C or 8086 assembly language.

Compiler	Source File Size (K bytes)	Pass 1 Compile Time (seconds)	Rel File Size (K bytes)	Pass 2 Compile Time (seconds)	Object File Size (K bytes)	Link Time (seconds)	COM/EXE File Size (K bytes)
Microsoft FORTRAN and Microsoft Linker for CP/M-80 (with floppy disk)	2*	7	2	—	—	13	8
Microsoft FORTRAN-77 and Microsoft Linker for MS-DOS (with hard disk)	0.25	8	1.38	13	0.84**	40	31
Supersoft FORTRAN-66 and Microsoft Linker for MS-DOS (with hard disk)	0.25	5	0.5	5	0.75	43	20

*This size is due to the operating system rather than the compiler
**A 15K-byte scratch file was also used

Table 5: *The compile and link times for three compilers, as well as the size of the output files for the smallest program I could write.*

Compiler	Hardware	Execution Time
Microsoft FORTRAN	4-MHz Z80A	40 min
	4-MHz Z80A with 9511 and 9512 coprocessors	8 min, 38.0 sec
Microsoft FORTRAN-77	4.7-MHz 8088 without 8087	10 min
	4.7-MHz 8086 without 8087	6 min, 44.0 sec
	4.7-MHz 8088 with 8087	57.0 sec
	4.7-MHz 8086 with 8087	40.7 sec
	4.7-MHz 8088 with in-line 8087	33.0 sec
	4.7-MHz 8086 with in-line 8087	26.7 sec
	8-MHz 8086 without 8087	4 min, 1.3 sec
	8-MHz 8086 with 8087	24.3 sec
	8-MHz 8086 with in-line 8087	15.7 sec
Supersoft FORTRAN-66	4.7-MHz 8088 without 8087	7 min, 40.0 sec
	4.7-MHz 8086 without 8087	6 min, 50.0 sec
	4.7-MHz 8088 with 8087	2 min, 1.0 sec
	4.7-MHz 8086 with 8087	1 min, 32.0 sec
	8-MHz 8086 without 8087	3 min, 29.0 sec
	8-MHz 8086 with 8087	55.1 sec
Unix FORTRAN-77	10-MHz 68000 software	2 min, 14.0 sec
DEC VAX FORTRAN-77	DEC VAX 11/780 with floating point	3.0 sec
IBM FORTRAN-66	IBM 4341 Model I with floating point	2.3 sec
IBM FORTRAN-77	IBM 3081D with floating point	0.3 sec

Table 6: *Compiled IEEE program execution times. "In-line 8087" means that the compiler has been set to assume that an 8087 coprocessor is available.*

The clear winner in compile and link time is Microsoft's FORTRAN compiler for CP/M-80 computers. It is also a single-pass compiler, which means it takes less total time to compile code.

Table 6 shows the results of a traditional execution-speed test. I used the IEEE (Institute of Electrical and Electronics Engineers) digital-signal-processing Remez exchange program as a representative number-crunching program rather than one of the classic benchmark programs. Because the IEEE program can be run in 64K bytes, I was able to use the program on all the computers.

No clear software winner emerges because the hardware makes so much of a difference. But, in terms of FORTRAN execution speed, the best microcomputer software-and-hardware combination is Microsoft's FORTRAN-77 for MS-DOS and the Otrona Attache or Seattle Gazelle computers. This combination completed the IEEE program in 15.66 seconds.

In a final benchmark, I tested video-screen I/O. The test consisted of writing 100 lines to the screen. CP/M-80 version 2.2 scored 5 seconds on the Otrona Attache 8:16; MS-DOS version 2.0 scored 17 seconds on the IBM PC. Both computers used I/O-mapped video via the operating-system console calls.

It's important to remember that the benchmark results are not the only thing to consider. You also have to consider price versus performance, price versus product support, price versus legacy, and what your application of the compiler will be. Perhaps in your application of the compiler, fast compile times mean nothing but price means everything. Remember to give benchmark results their proper rank in the hierarchy of compiler features that are important to you.■

Acknowledgments

While I have read a few books on the theory and design of compilers and operating systems, I could not write a compiler or operating system. Even though I feel that I am fully qualified to benchmark compilers and to contribute suggestions for enhancing them, I would like to acknowledge the programming effort, R & D funds, marketing expense, and product support that go into each and every compiler. Hats off to all.

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Benchmark Confessions

A close look at sometimes subjective tests

by Peter Marvit and Mohandas Nair

Everyone has opinions on three subjects—sex, religion, and benchmarks. While the first two are influenced by cultural and personal tastes, benchmark results often masquerade as objective fact cloaked in scientific methodology and absolute numbers. Figures don't lie, but liars figure, as the saying goes, and benchmarks are prime targets for selective interpretation and general confusion.

In presenting our philosophy of benchmarks in this article, we will focus on complete computer systems, but the principles involved are general and can be adapted to cover specific peripherals. We have not tried to encompass the entire field of benchmark methodology, but rather, provide guidelines and considerations for all who read and perform benchmarks—computer users, salesmen, and designers. Benchmarking is, at best, problematic, and at worst, a gross distortion of reality, but you can make the best of an impossible situation if you enter this fray armed with specific directions.

When we look at the role of benchmarks we need to ask questions, such as: What are they? Who uses them? How are they used? Understanding the background and intentions of benchmarks is the key to interpreting the results. How those results are reported is also crucial. Complete information must be given if the results are to be meaningful. We recommend a point-to-point list of what may be included in a good benchmark write-up. The delicate issue of benchmark design and validity requires a great deal of thought. This article skims over many parts of the problem and points toward several avenues of investigation.

The Role of Benchmarks

A benchmark is an objective, reproducible measure of performance (e.g., execution-speed comparisons, object size, or device interrupt latency measures). It assists us in placing system performance within a continuum, be it a list of times measuring I/O (input/output) performance, or the like. Thus, from an individual standpoint, benchmarks are a means of comparing one system to others. Benchmarks form a strong feedback mechanism to manufacturers and software designers so that they can gauge how their creations will rate in the marketplace. However, the inherent attractiveness of using benchmark reports in advertisements demands of the buyer the skill of differentiating the sales pitch from the benchmark information. But even if we have this skill, what's so important about benchmarks?

A computer purchase is roughly analogous to buying a car. Obviously, the decision-making process varies but very few people only think about performance and nothing else. Clearly, many other factors may be brought into the decision-making process. Benchmarks are but a part of the selection, decision, or evaluation process. Some individuals take benchmarks very seriously while others are unaffected or not highly influenced by them. All in all, benchmarks have a place in the comparison/evaluation process.

The Audience

We classify the audiences for benchmarks into *engineers (makers)*, *marketers (sellers)*, and *users (buyers)*. Each has its own needs and methods of evaluating benchmarks. The engineer wants to optimize the system's design. The benchmark is a test that analyzes parts of a computer system and displays bottleneck areas or poorly performing components that can be improved. By varying a single element in the system, an engineer can improve the system per-

formance, using a benchmark program as the measuring instrument to compare one system configuration against another.

Marketing people want to sell a product. They would love nothing better than a single number that conclusively shows that their computer outperforms the competition. Benchmarks also provide some indication about who the competition really is and what market niche the computer should target. Unfortunately, benchmark results serve as little more than advertisements.

Finally, the user wants objective comparisons between the different computer systems he might purchase. Benchmarks appeal to his need for (theoretically) unbiased reporting of a system's performance.

However, each user's needs vary depending on experience. Of course, the ideal solution to benchmarking is to take the final applications that the users perform and run them on the various computers. This usually proves impossible, especially for complex applications. To further the problem, future needs can rarely be anticipated and so any testing will be speculative. Again, this leaves us looking at existing benchmarks, armed with the ability to discern fact from advertising hype. Hence, let's consider how benchmarks are misused, in our attempt to isolate a solution.

Misuses of Benchmarks

In benchmark reporting, we have discovered a very narrow but distinct path between truths and lies. Developing the skill of telling not-really-the-truth and not-downright-lies is important for successful benchmarking. Many people look upon benchmarks as marketing hogwash, only coincidental with facts.

Ironically, incomplete information is as dangerous as lying in the benchmark world. Consider an article published in EDN magazine highlighting a Unix-based benchmark with performance numbers for various competitive systems (see reference 1). Under the subheading "Test Results Tell the Story" we read, "System capabilities are subject to interpretation, but the results of a simple benchmark provided by the manufacturer tend to support claims of fast processing."

But results don't tell the story. The story requires much more information such as details of configurations used, the methodology used in tests, etc. A comment on performance serves no purpose to the true benchmarker, but feeds incomplete information to readers who enjoy sweeping, unsupported ideas, even if true.

Ironically, we received a copy of a benchmark report, generated by Teus Hagen and Andrew Tenenbaum from Amsterdam, entitled "Two Programs, Many Unix Systems" (see reference 4) that highlighted the same processor-bound benchmark program. They ran this program on a multitude of competitive systems. With amazing coincidence, the results they derived on the systems were identical to those published in the EDN article. However, Hagen and Tenenbaum drew the following conclusion: "None. You should take these measurements with a grain of salt, or better yet, an imperial gallon of salt." In two reports with the same results, we encounter two different messages. Such situations are common but this does not negate their contradicting effect on a fast-reading, often overlooking audience. Possibly, further detailed information could clear up any confusion about how these conclusions were derived.

Benchmarks indicate who the competition really is and what market niche a computer should target.

But the lack of detailed information is not the only stumbling block in benchmark reporting. For example, consider person M who endeavors to buy a used car. M visits a reputable dealership, isolates a few choices, and finally decides on a beautiful car that has been kept indoors, under beautiful lighting. The car is dry, clean, and reasonably priced. M purchases the car, drives it off the lot, and discovers, on a rainy day, that the car leaks. Benchmarks can provide a showroom atmosphere to flawed products in a similar manner. By highlighting the good and overshadowing flaws, a benchmark report can deceive an audience until that terrible rainy day.

Picking Valid Benchmark Reports

As we discussed before, benchmark reports can deceive more than inform by giving incomplete data. However, the effect that benchmarks have on us can be approached rationally—as rationally as one approaches any form of advertising without discounting everything. The following considerations may assist in developing this rational approach toward reading and writing benchmarks by being less caught up in the results and more involved with how the information is presented. Look at any benchmark report and consider the following:

- Who originated/authored the report? Obviously a report on the XYZ computer done by the company that created the product will show the XYZ to be successful. Unbiased reports are hard to obtain but one technique would be to get benchmarks from other companies that include the XYZ computer in their reports as a competitive measure. Thus, if you want to benchmark XYZ, don't obtain benchmark reports from them, ask other companies for their reports that involve XYZ. Chances are they would report on the XYZ rationally.
- Determine the objective of the report. Here emerges the need for abstracts, detailed introductions, and summaries. Readers usually tend to read the introduction, the graph, and run to the conclusions of a benchmark report; thus, the need to identify and establish the message in any report. If you don't get the message clearly, drop the report—it will do more harm than good. Examples of clearly directed reports/articles are references 5 and 13.
- Descriptions are needed of the methodology used. Without a suc-

cinct description of how the benchmarks were performed, there is no use describing the results. The reader wants to reproduce these results to completely trust them, and comments on the technique used would be helpful. Descriptions of the programs or benchmarks used and further descriptions of the environments where testing took place are crucial to a successful benchmark report.

- Are source listings provided? Documented source code or listings of the actual benchmark program will give the readers a clearer understanding of what was performed. From this, we can reproduce the benchmark and criticize or applaud the technique. There's something about actual code that makes it all seem so technical and accurate.
- Detail the systems used in the benchmark. The report should give exact detail about the systems on which the benchmark was run. This would guard against readers who assume too much about the results obtained or the use of systems that are unmarketed, souped-up versions used only for the benchmark. Still sticking to our concern for reproducibility, we need details of the system configuration. The system configuration should be included in any benchmark report.
- Results are never forgotten. Benchmark reports always display results, results, and results. "We beat them by 5X (times) performance difference" is all we hear. The public seems to crave a single, definite *X* value that, to them, describes complete system performance in comparison to other competitive systems. We realize that an average number like 1.5*X* or 2*X* is nothing but an average estimation of comparative system performance. Comparative *X* values are useless unless the results are linked with what is being compared; e.g., 2*X* (times) better than system Y in I/O capability.

Benchmark results are usually represented graphically as well as in raw number form. We suggest that results be displayed in absolute raw numbers in combination with either a relative graph or an absolute graph.

The main aim of benchmark reports is to inform, display results, and discuss findings. As in any scientific experiment, raw numbers or graphs are irrelevant scribblings without careful analysis and interpretation. In other words, when you hold a benchmark report in your hand next, look for a position or conclusions taken by the author. If the author has not made one, don't make one yourself.

Benchmark Design

Questions about benchmark programs and their design still remain. A look at benchmark programs today is a study in dichotomies: simple single-task processes vs. complex multitask global programs. Current taste favors the former.

If the author of a benchmark report has not made a conclusion, don't make one yourself.

First and foremost, small single-task programs are easier to use and understand. People can usually comprehend their purpose and method without difficulty. They seem to test a single element in a computer system (e.g., processor speed, disk access, etc.). Like minimalist art, streamlined programs have an elegant aesthetic. Because they are (presumably) easy to run, reproducing results presents few problems. These small programs often suffer from their simplicity, however. As mentioned before, the well-placed spotlight of a single benchmark focuses attention on one aspect of system performance, ignoring the rest. The question of exactly what the one program actually measures rears its formidable head again.

The gargantuan global benchmarks provide a stark contrast. Usually transported via many reels of magnetic tape and the child of laborious years of effort, these complex tasks require considerable expertise and time to set up and run. They produce voluminous statistics on many aspects of a system's performance. Since their design supposedly reflects the requirements of typical computer loads, the results should predict real-life situations. Unfortunately, the global benchmark design is frequently not independently verified and the results are often cryptic—hardly the stuff for managerial decisions. Completeness can also be a problem. One missing software utility used at the beginning of the benchmark stymies the rest of the run since subsequent tests rely on previous results. To compound the problem, standardization from system to system is difficult due to differences in language and operating system versions, enhancements, and omissions.

One approach to system benchmarks is to use the following paradigm. To admittedly oversimplify the matter, a system benchmark could consist of an I/O loop and a central processing unit loop. You introduce parameters that determine how many times the individual loops are iterated. That way, you can have a program that is as I/O-bound or processor-bound as desired. To test different application conditions, you merely vary those parameters and the number of programs running concurrently. This conceptual model offers four advantages: (1) basic modules can be easily coded; (2) each module can test a discrete function; (3) individual modules are easily run and understood; (4) programs can be combined to produce complex tasks that simulate real-world applications.

Many problems and considerations are inherent in benchmark implementation. The actual coding is nontrivial. For example, each language has certain strengths and weaknesses, but a programmer must be careful that the benchmark measures system performance and not his or her own cleverness. Certain languages (and hardware, for that matter) tempt the programmer to use tricks that bias the test. For example, a microprocessor might decrement faster than add and so appear faster with an addition-only program. Code transportability must be considered. Benchmark programs should be doc-

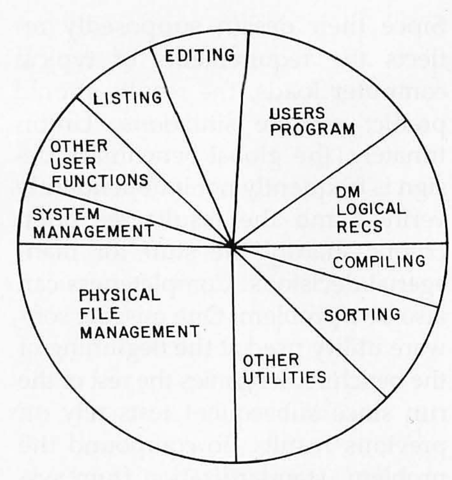


Figure 1: *Estimates of the job functions performed by a typical microcomputer system.*

umented and conform to commonly accepted language standards.

Compiler efficiency also has a tremendous impact on system speed. Assembly-code can circumvent this problem but introduces computer-specific dependencies. How a higher-level language is implemented might provide hidden optimizations; two different compilers operating on the same source code can produce dramatic differences. In this light, and considering language structures, benchmarking using two *different* languages is ludicrous.

Determining the importance of each portion of a benchmark requires a good understanding of a computer system's actual use. Many operating systems can provide empirical data about what tasks are performed how often using what resources. Figure 1 shows one possible job mix on a medium-sized computer.

To design even an individual benchmark module, you must clearly define its purpose. An ill-conceived program can measure many aspects of a system—none of them properly. A well-constructed and targeted program can effectively focus on a single performance element and form a valid building block for a benchmark. For example, an I/O loop might exercise moving data within pages in memory, from disk to disk, from memory to disk, etc. You must isolate individual performance factors, without getting caught up in little details, until you form an adequate model on a computer system.

Benchmark designers and discerning readers must remember that different types of users need different benchmarks. Special consideration is necessary to fulfill the needs of office automation, word processing, scientific, multiuser, or database applications. Indeed, system performance in each area depends on the proper match of hardware and software as well as basic computing speed. For example, the public is acutely interested in benchmarking multiuser environments, although they are especially difficult to measure accurately. The entire topic of benchmarking requirements covers a wide and barely touched area. Given the confusing variety of factors involved in benchmarking, it's a wonder that anyone even attempts such an onerous task.

Conclusion

In this article, we have attempted to explain a formalism that creates a framework for credibility in the development and reporting of benchmarks.

There is still much more to investigate and discuss. We hope that areas such as detailed benchmark design for specific applications, actual mechanics of benchmark execution, benchmark evaluation, and the possibility of standardized benchmarks will be attacked and covered in the future. Unfortunately, in the benchmark world, it's not who knows but who shows that counts. We have no lemon laws for benchmarking that guard against misrepresentation. But we do have methodologies and general techniques that assist us in our understanding or development of benchmarks.

The role of reader is seldom confronted but demands mention. The audience, if polite, will permit misrepresentation in benchmarking and if aggressively critical, will nurture clear and honest benchmark reporting.

In short, this article is not a thorough treatment of the deep subject of benchmarking. Consider this as a starting point for discussion and ammunition against credible reports. We encourage you to read the references for more insight. We are also anxious for your opinions and involvement in this controversial subject.■

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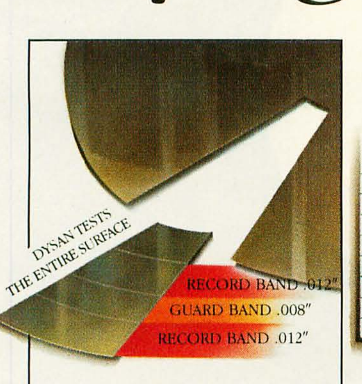
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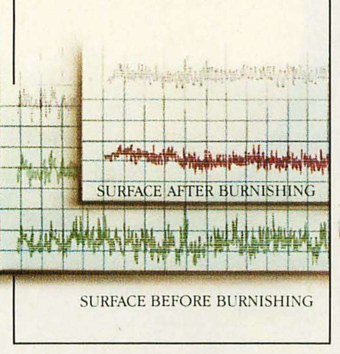
The authors would like to thank Gene Dronak of AIM Technology, David Billstrom of Oregon Software, and Madeline for her inspiration and help.

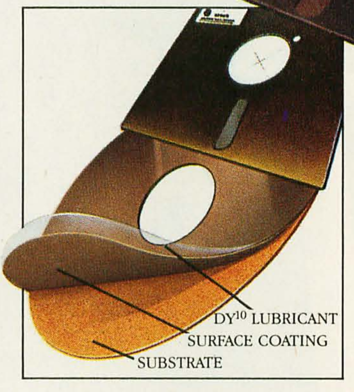
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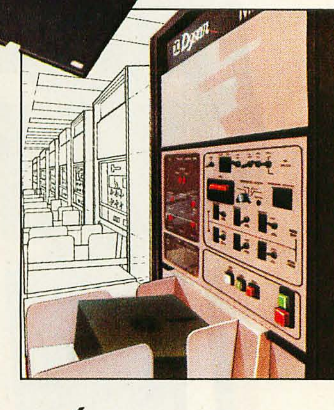
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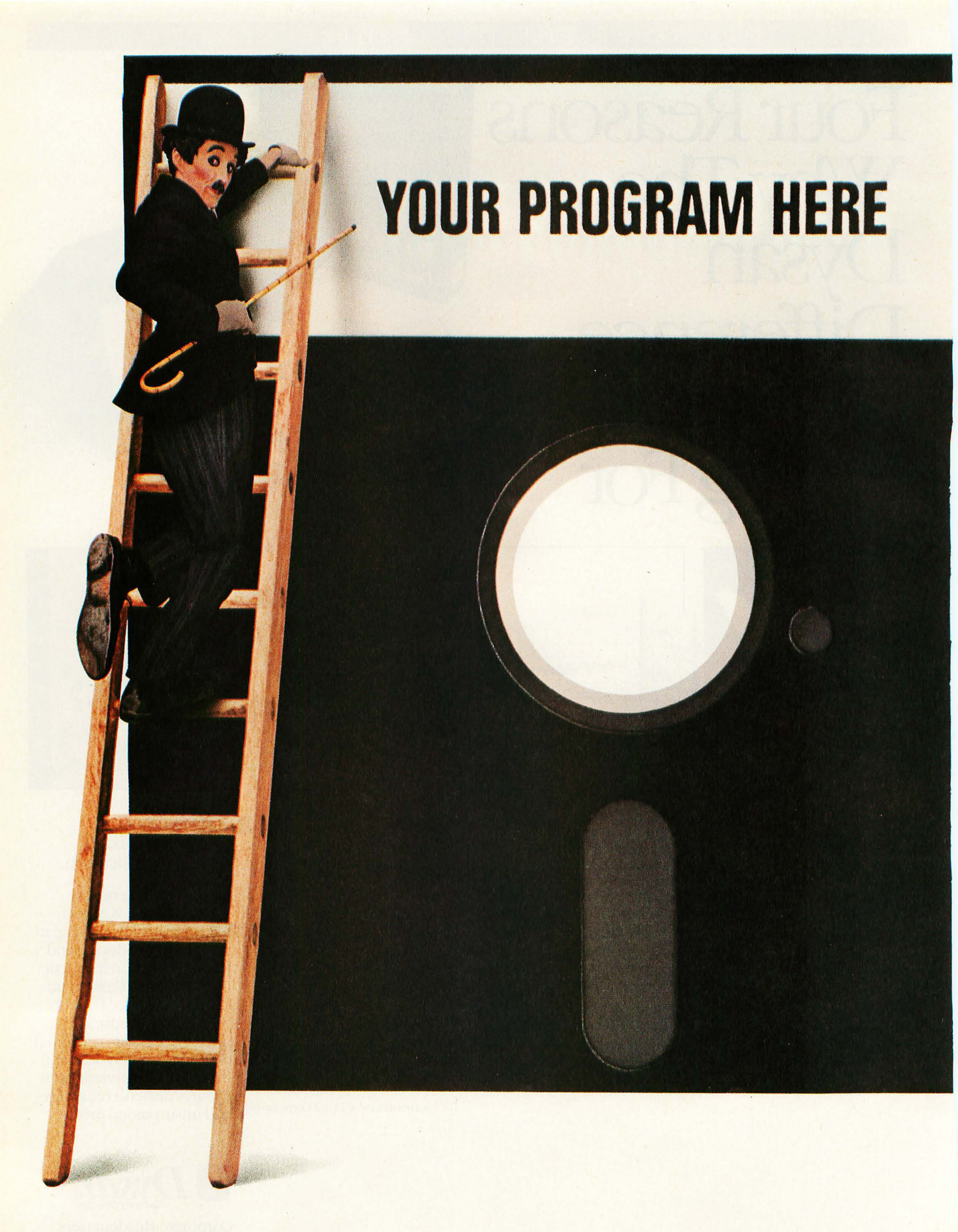
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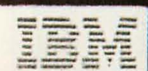


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We're Driving the Drive Market.

The Word-Processing Maze

How to find your way through all those "new" features

by Andrea Lewis

If you're in the market for a word processor, you might feel safer buying some land in Florida. Wild claims seem more prevalent than usual as more and more companies square off on the already-scarred word-processing battlefield. Only certain species of rabbit are known to produce more "generations" than the word-processing industry.

If you trust the comparison charts, you buy the program with the most red dots next to it. But is it that simple? What's really going on? What is a "style sheet"? Do you need horizontal scrolling? Do you need the features of a "dedicated" word processor? What if you're "dedicated" to your old word processor?

It's true, word-processing software is getting better all the time. With 16-bit computers and more sophisticated screens to run on, word-processing programs are adding features, dropping prices, and trying every gimmick to get attention. This article describes some new features you'll be hearing about and will help you create a mental checklist of what you want in your next word processor. (Also see "Evaluating Word-Processing Programs" on page 243.)

If you're in a store where you can test one of the new dazzlers, start by typing in some text. This is a little like kicking tires, but it does tell you some things. Watch for wordwrap at the right margin of the line you're typing. If a word won't fit on the line, it should automatically move down to the next one. (Reverse wordwrap—good buzzword—occurs when you delete something and words from below move up.) Not only is this quick and handy while you're typing, but it indicates the much broader design concept of automatic reformatting.

Most of your text entry is in insert mode, but make sure you can switch to overtype mode—replacing existing characters as you type. It should be available as a simple toggle and comes in handy for some editing operations.

Be Selective about Selecting

Next, most people try out one of the Big Three: Delete, Copy, or Move. To perform one of these operations, you must first choose the exact text you want to work on. Stop for a minute, take your attention away from the commands themselves, and consider the process of selecting text. This single process will, in time, cause you immeasurable grief if it is the tiniest bit awkward, slow, or difficult.

The system should provide many options for selecting the text you want. Imagine the agony of selecting every word character by character or every sentence one word at a time. Look for fast, flexible text selection: by character, word, sentence, and paragraph—with options to extend to multiples of each item. The use of a mouse makes text selection much easier.

Before you can select text, you must position the cursor in the right vicinity, involving some combination of scrolling and cursor movements. A mouse is handy because you can scroll by variable amounts using the scroll bars. If you are going to scroll with the keyboard, the system should implement Page-up and Page-down keys to move you up or down by one screen. To scroll longer distances, look for Home and End keys, a jump to page n command, and the ability to mark text and jump to marker x.

Horizontal scrolling is a necessity

now that most word processors permit very wide documents. Find out which keys move the document left and right and in what increments.

No Big Deal

You were about to carry out a command before text selection, cursor movement, and scrolling sidetracked you, so now turn your attention back to the command interface. You should be able to see the main command menu on the screen while you are entering text. Find out how easy it is to choose a command, by pointing at it (using keys or a mouse) or by typing its first letter. Look for ease in moving back and forth between insert mode and the commands; it shouldn't be a big deal. Try some simple editing commands like Delete and Copy to see how easy or difficult it is to choose commands.

Reserve judgment on the command interface as a whole until you look at the more intricate commands, those with a submenu or more than one field to fill in. The important thing here is that, as much as possible, the commands be task-oriented, so that all the information you need is in one place. For example, the Replace command should prompt you for all the information it needs: the search text, the replace text, the direction of the search (forward or backward), and if it is case-sensitive and whole-word-sensitive. (Whole-word-sensitive means don't find occurrences of the search word within other words. Case-sensitive means search only for text in which the uppercase and lowercase letters match the search string. Some new systems do case-sensitive replacements automatically, that is, if the replacement word begins a sentence, its first letter is automatically capitalized.) You should also be able to specify confirming or nonconfirming, that is, whether you want to individually approve each replacement or globally replace all occurrences at once.

It is important to notice how logically and efficiently the command interface is organized. Check to see if the command fields are filled in automatically with defaults or likely responses. It is desirable to have commands with lots of options, but you don't want them to obstruct what you do 99 percent of the time.

The Formatting Jungle

The term "formatting" covers a lot of ground in word processing. How do you get from screens full of free-form text to the printed page with running headers, page numbers, centered titles, paragraphs, sections, tables, footnotes, and bold or italic characters? And how much of this can you see on your screen during editing? Functionally and visually, formatting features on microcomputers are finally meeting—or surpassing—those on dedicated word processors.

You'll keep hearing the phrase "what you see is what you get." It means that the word processor *automatically* reformats all the text while you are working, so you always see a reasonable facsimile of the formatted document on the screen. If there really is a next generation on the way, automatic reformatting is its single most distinguishing feature. The screen looks just as it's supposed to, without gaps after a deletion, without unjustified margins when they should be justified, and without Reformat keys or commands. Instead of control codes indicating bold or underlined letters, the letters appear bold or underlined. Centered text stays centered, even if you change its length. You get the idea.

In short, the formatting actions are not only automatic, but, once assigned, they become implied in the text. Special formatting commands assign the formatting properties that are not visible within the text itself. It's a subtle concept, but one that judges the effectiveness and elegance of a system's formatting repertoire.

A few formatting techniques require special mention:

Formatting tabs: tabular material was a problem in the past because word processors simply expanded tabs into spaces. If you changed the number of characters between tabs, you threw the alignment off. Today, real tab stops exist, which are a lifesaver for anyone working with columns. Look for a specific tab-setting command and the ability to see tabs on a ruler on the screen. Also look for alignment selection—left, right, center, or decimal—for the text at any tab stop. And, if you're really serious about tables, look for column operations, such as deleting an entire column or adding the figures in a column.

Formatting running headers: usually, word processors keep text for running headers in one place and then print it on each page. Look for the following options for formatting running headers: positioning at the top or bottom, different text for even and odd page numbers, expanding page numbers within the headers, and changing or eliminating the header on the first page. The package should allow any number of lines in the running header.

Formatting footnotes: at last, some microcomputer word-processing systems include specific commands for footnote management. If your work includes any documents requiring footnotes, don't settle for a system that doesn't handle them. Your word processor should number the footnotes and automatically put footnotes and their references on the same page during printing. There should also be an option to print all the footnotes at the end, if you prefer. Since the footnotes are usually stored at the end of the document during editing, some systems provide a footnote window that you can open to edit the footnotes without losing sight of the main text.

Format definitions: the ability to create format definitions rather than the formatting macros of yesteryear is in the works. Format definitions (or style sheets) are powerful tools, especially if you want a standard format for a certain type of document. The format definition is an entity, separate from the text, that the user creates to describe certain format properties. It includes such formatting information as indents, justification, running headers, font names, double-spacing, and tabs. If you store the formats separately and apply them to the documents later, you can establish standards for company documents or for your own use.

Getting What You Saw

Be sure the word processor you buy works with your printer and takes full advantage of it, that is, be sure it has the correct printer description file. If your printer has proportional fonts, make sure your system supports them. The word processor must know the width of every character in the proportional fonts you use to calculate line breaks and justify the text. Find out if the printer description file has all the information you need. To justify with proportional fonts, most systems microspace between words, making the space between words on a line equal. Your output looks even better if the system microspaces between the letters of the words.

Other print options to look for include choice of continuous or sheet-fed paper, background printing, and prompts for font (print wheel) changes during printing. Most new systems also offer *direct print* (or hot print), which lets you type directly from the keyboard to the printer—handy for addressing a quick envelope.

Currently, no microcomputer word processors display text in two or more columns on the screen and reformat them as you type. [**Editor's Note:** *There is now at least one: Jack II for the IBM PC from Business Solutions.*] A few let you enter text as usual (in a single column) and then specify more than one column for printing. The system wraps and justifies the columns before printing, and you get multicolumn output. This is a good feature, especially if you print a newsletter or brochure with your word processor.

I Take It All Back

For the "what have I done" and the "oh no," an Undo command is a must, and most word processors today implement one. The Undo command takes back your last action, as if you never did it. The Undo command responds in two possible ways if you execute several in a row. It may undo only the most recent action (even if that action was an undo), or it may work successively backward through your actions, undoing each one in turn. Both are useful. You can experiment with formatting by undoing your most recent action. Change some formatting, look at it, undo it to compare it to the original, and so forth. How much text can the Undo command handle? The worst errors are usually the ones involving the most text, so it defeats the purpose of this command if there is much of a limit.

Chunky

All good word processors have a way to expand user-assigned abbreviations into their longer definitions. A glossary (or boilerplate) is a real time-saver for anyone doing business or legal documents. First, you assign abbreviations to chunks of text, such as the paragraph that describes your warranty or a phrase like "the party of the first part." When it's time to insert the text into the document, you simply type the abbreviation and expand it. The important questions are how many abbreviations can you have, how long can the chunks be, and how easy is it to do the expansion? It's supposed to be a time-saver, so a single keystroke should expand the abbreviation.

Mouse Pointers

The initial reaction to using a mouse with a word processor is usually: "I don't want to keep moving my hands on and off the keyboard." Well, that's true, you don't. Depending on how well the program differentiates between text entry and editing and formatting, the mouse can really shine at selecting text and commands. It allows easy scrolling and text selection. To carry out a command on the selected text, point the mouse at it and push a button. If the system is designed for this device, lots of operations can be performed only with the mouse. Of course, any system that works with a mouse should also have a keyboard equivalent for every function.

Window Shopping

A good system allows two, maybe more, windows open at once. Look for a Window command with the option of opening it vertically or horizontally. You want the ability to see different parts of a document, or different documents, through the windows. It should be easy to cross window borders and to copy or move text from one window to another—sometimes called cut and paste. Multiple windows allow you to see what is happening when you merge documents. Make sure you can merge at any location in a document, not just at the end.

Spelling and Hyphenation

To cut down on overhead, most systems don't build in spelling or hyphenation utilities but rather provide them as separate utilities. Hyphenation can exist with varying degrees of accuracy. Some programs hyphenate according to a set of rules about where it is safe to insert a hyphen (before "ing" or between double consonants, etc.). If an on-line dictionary already exists for spelling, the hyphenator should use it to look up proper hyphenation. This is slower but more accurate. Some spelling checkers also provide minor syntax checking, such as alerting you when you type the same word twice in a row.

Still Waiting

So far, generating an index or a table of contents automatically is still the exclusive property of dedicated word processors or mainframe programs. Look for these features on microcomputers 12 to 18 months from now.

Summary

I hope this list of new word-processing features helps you weave your way through the ads, brochures, and demonstrations. Plan ahead for the features you want and need so your word processor will be viable for years to come. In addition, don't lose sight of such design qualities as automatic reformatting, easy text selection, and a logical command interface. They make a real difference in efficiency and ease of use in the long run. ■

Andrea Lewis (1034 N.E. 90th St., Seattle, WA 98115) is a freelance writer.



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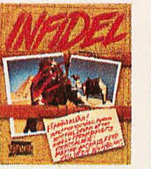
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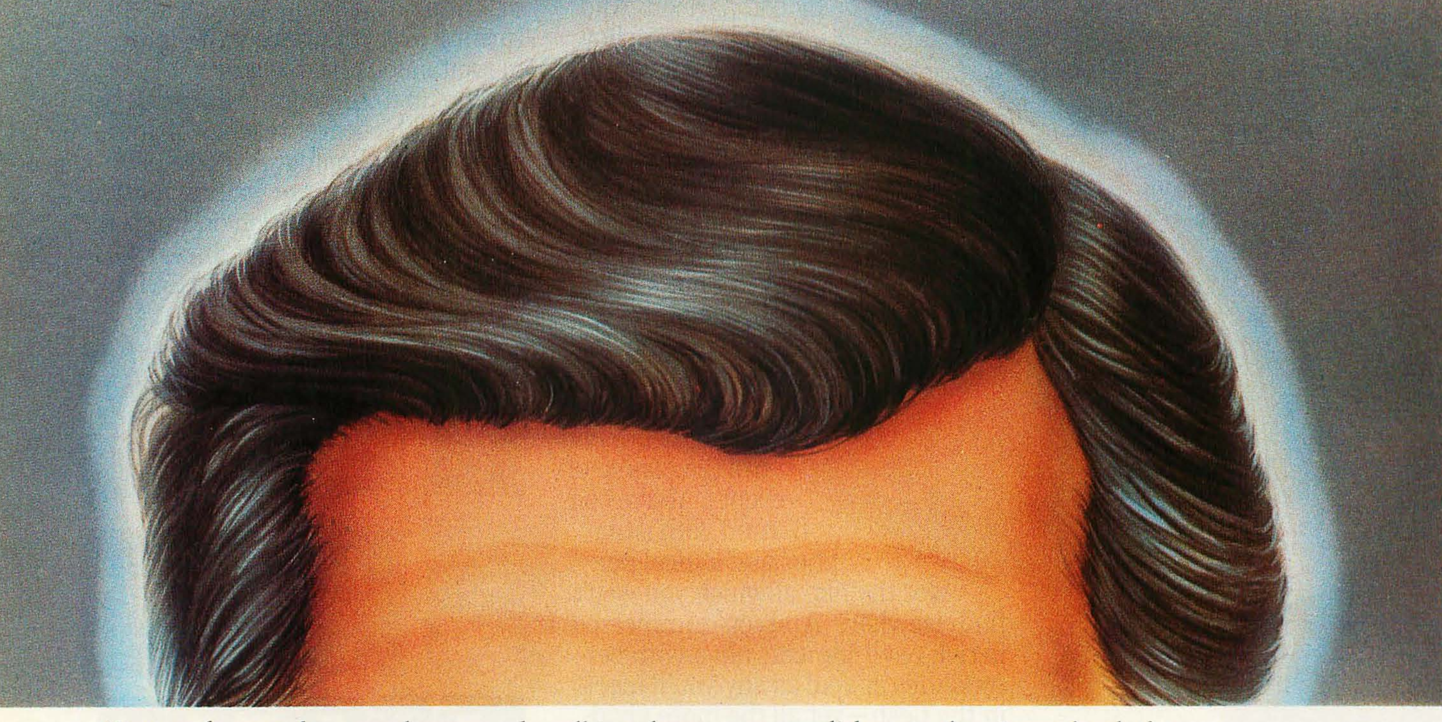
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Evaluating Word-Processing Programs

A 100-point checklist simplifies the decision-making process

by Arthur Naiman

How to Keep Score

In the case of all yes/no questions, yes is the answer that earns the points.

When keystrokes are being counted, control characters count as a stroke and a half. So do shifted characters. Shifted control characters—or any other combination of three keys you have to hold down at once—count as two keystrokes. If a program can't do the function at all, it gets a five-keystroke penalty.

Count cursor arrows with autorepeat for a minimum of 3 (it takes a while to get started) and a maximum of 10 (to move from the top to the bottom of the page or from one end of a line to the other).

If a question asks, "Is there a one-stroke command to ...," count control characters (but not shifted control characters or other three-key commands) as one stroke.

This article is reprinted by permission of McGraw-Hill Book Company from Word Processing Buyer's Guide *by Arthur Naiman (New York: McGraw-Hill, 1983).*

Since some microcomputer keyboards have special function keys like those on dedicated word processors, and since certain word-processing programs have been designed to work with them, such programs may get different scores, depending on the system they're used on. But for dedicated word processors (which always use the same hardware), and for word-processing programs that can't take advantage of special function keys, the score won't vary.

If a file name is required, assume it consists of eight characters. Be sure to include *every* keystroke—Return, Enter, etc. Remember that you can give partial points (for partial performance) on any item.

Since the checklist is so long, I've boldfaced certain key words throughout, to help you find particular items more quickly and easily.

Safety and error handling—10 points

How hard is it to **lose text**? (4)

Are there hard-to-avoid fatal error(s) that are likely to occur:

- about 1% of the time? (−25)
- about 2% of the time? (−50)
- about 3% of the time? (−75)

How well are **errors documented**? (2)

How clear are the error messages? (1)

Is verification of **saves** automatic? (1)

Are backup copies automatic? (1)

Can you save to either disk, or switch disks without exiting the program? (1)

Subtotal for safety and error handling:

Documentation—18 points

Is the **training manual:**

- well-organized? (3)
- readable? (3)
- complete? (1)

Is the **reference manual:**

- complete? (3)
- well-organized? (2)
- understandable? (2)

Is there a good, complete **index**? (1)

Are the manuals **typeset**? (1)

- If not, is the text proportionally spaced? (½)

Is the layout intelligent and the **design** graceful? (1)

Are there **special kinds of documentation,** other than manuals (like a

reference card, on-screen tutorial, training tape, etc.), that you find useful? (1)

Subtotal for documentation:

Ease of use and human engineering—18 points

Is the **workfile held** in **memory** or **on-and-off disk**?
(no score, but an important consideration)

How many keystrokes does it take to go through the following **sequence of 23 commands?** __________

1) open a new text file (don't count the characters in the file name itself);
2–4) center, boldface, and underline a title;
5) skip a line;
6) indent the next line of text 5 spaces;
7) indicate the end of that paragraph;
8) skip a line;
9) indent the next paragraph 5 spaces;
10) put a page break at the bottom of that paragraph;
11–14) reset the top, bottom, left, and right margins (just count the commands, not the numerical values);
15) order the file to be double-spaced (if single-spaced is the default), or vice versa (again, not counting the numerical values);
16) save the file;
17*) print it out;
18*) stop in the middle of printing out;
19) return to the text;
20) delete a word (5 characters and a space);
21) delete a line (60 characters or more);
22) save this new version of the file, keeping the old version for backup; and
23) begin printing out again at the top of the page.

[*Systems with virtual representation can skip these two steps (17–18), since it's just as likely that a mistake will get caught on the screen as in a printout.]

Fewer than 55 strokes—5 points
56–60 strokes—4½ points
61–65 strokes—4 points
66–70 strokes—3½ points
71–75 strokes—3 points
76–80 strokes—2½ points
81–85 strokes—2 points
86–90 strokes—1½ points
91–95 strokes—1 point
96–100 strokes—½ point
more than 100 strokes—no points

How **easy** is it **to remember commands** (thanks to mnemonics, cursor diamond, and other logical key placement, menus, logical command structure, reference card, key tops, dedicated keys, reconfigurable commands, etc.)? (3)

Is the main editing **menu suppressible,** or not normally on the screen with the text? (½)

Is there a way to know:
what **page** of the printout you're on? (½)
your **location** with respect to the entire file (what percentage of it is behind you, for example)? (¼)

Can you **find** out the **total size of the file** you're editing without exiting the program? (½)

Can you do that and return to where you were in the file in less than 3 keystrokes (or two control characters)? (¼ additional)

Can you **copy the program** as often as you need to? (2)

Total program size:
Less than 25K? (1) 25-35K? (½)

Or—on dedicated word processors, and other systems where the software and hardware are integrated—
Workspace more than 30K? (1)
Workspace more than 20K? (½)

Are the **editor and formatter** loaded **together**? (1)
If not, can you keep the workfile in RAM while switching from the editor to the formatter? (½)

How often does the **program** have to go to the disk to access **overlays**? (never, because whole program resides in memory—1; only goes to overlays occasionally, for special jobs—½; overlays are essential part of program—0)

Can you:
rename the file you're working on without abandoning the edit? (¼)
rename a file other than the one you're working on without leaving the program? (¼)
delete a file other than the one you're working on without leaving the program? (¼)

Can you get a **directory** of files on the disk without exiting the word-processing program? (—1 if not)
Does this directory also give you the size of each file? (½)
Can you ask for just part of the directory? (¼)
Is there a **type-ahead buffer (keystroke storage)**? (1)

Will this program run **memory-mapped**? (½)

Subtotal for ease of use:

Editing power—25 points

What is the **total number of commands** this program offers you (for editing, formatting—everything)? [Count every possible option.]

more than 170—4 points
150–170—3½ points
130–149—3 points
110–129—2½ points
90–109—2 points
70–89—1½ points
50–69—1 point
30–49—½ point
fewer than 30—no points

Is there **wordwrap**? (1)

Ease and power of **basic** cursor movement, insertion and deletion **commands** (6)
[The next 16 questions will give you a reasonable score for this item for programs that use conventional techniques. For other programs, you have to make this judgment subjectively.]

Is there a one-stroke (or one-control-character) command to **move the cursor**:
right one character? (—1 if not)
left one character? (—1 if not)
up one line? (—1 if not)
down one line? (—1 if not)
(two-stroke or two-control-character commands count half for the next 11 questions)
forward one word? (½)
backward one word? (½)
to the end of the line? (½)
to the beginning of the line? (½)
to the top of the screen? (½)
to the bottom of the screen? (½)
to the beginning of the file? (½)
to the end of the file? (½)

Is there a one-stroke (or one-control-character) command to:

OVERALL SCORES	Version(s) (of software)	Operating system(s) and/or machine(s)	Price	Overall score	Safety and error handling	Documentation	Ease of use	Workfile in memory or on and off of disk	Editing power	Formatting power	Responsiveness and support
CPT 8100	G-2	ded. word proc.	$15,000	94¾	9	16¾	14¾	M	24	26¼	4
DICTAPHONE DUAL DISP.	D	ded. word proc.	13,500	85¼	7	16¾	12	D	18¾	26¾	4
PIE WRITER (W/ PRO/FORMAT	2.1 (2.2)	Apple II, Flex, IBM PC, TRS-80 Color Computer	200	84¼	9½	15	13	M	20½	22¼	4
A. B. DICK MAGNA SL	7	ded. word proc.	14,500	83	8	16½	9¾	D	19¾	25	4
WRITE	1.4	CP/M	400	82¼	10	15½	16¾	M	19	17½	3½
MICOM 2001	5.1R	ded. word proc.	12,000	82¼	7¾	15¾	10¾	M	20½	23½	4
WORD STAR	3.0	CP/M, Apple II, IBM PC	500	80	7½	11¾	13	D	21¾	22	4
NEW SCRIPT	7.0	TRS-80 Models I & III	125	79¼	8½	15½	12¾	M	18¾	19¾	4
WANGWRITER 5503A	3.1	ded. word proc.	6,400	74	8	16	13½	D	18¾	14½	3¼
WANG SYSTEM 5, MODEL 3	3.2	ded. word proc.	11,500	70	6	14¾	10¾	D	18	17¼	3¼
MINCE & SCRIBBLE	2.6 + 1.3	CP/M, UNIX, PDP-11	275	67¼	7	12¼	8	D	18¼	17¾	4
SCRIPSIT	2.0	TRS-80 Model II*	400	61½	2	14¼	7¾	D	18¼	16¼	3
MAGIC WAND	1.11	CP/M	400	61¼	3¼	12¾	8	M	17¼	20	0
EASYWRITER	1.0	IBM PC**	175	35	—24	14¼	11¼	M	12½	16¾	4

*Similar Scripsit program also available for Models I & III
**Very similar program called Easywriter Professional available for the Apple II

Table 1: *Composite scores of some word processors.*

delete a whole word? (½)
delete a whole line? (½)
switch between insert and write-over mode? (1)
either mode missing (—5)

Is there continuous and unlimited:
forward **scrolling**? (½)
backward scrolling? (½)

Can the **scrolling speed** be altered? (¼)

Can you **call** up any **page** in the text **by number**? (1¼)

Can you **move** the **cursor where** there is **no text**? (½)

Can you:
copy **blocks of text**? (¾)
move blocks of text? (¼)
delete blocks of text? (1)
make a new file out of a block of text without having to stop editing the file you're working on? (½)
insert another file into the one you're editing (½)

Can you:
find a string anywhere in a file? (1)
replace a string anywhere in a file? (1)
search **backward** as well as forward? (¼)
do many substitutions **all at once,** without having to approve each one? (1)

Can you **see each change** for approval if you want? (—2 if not)

In doing finds or substitutions, can you tell this program to **ignore caps/lowercase**? (½)

Look for **whole words only**? (½)

Can you:
make substitutions that affect more than one file at a time? (½)
store stock phrases in memory and insert them with a coded command while typing? (½)

Are there **other** special **global capabilities**? (¼)

Is there a command that **moves** the **cursor** to **where it was before** the *last* **command** was executed? (¼)

Is there a **split-screen** feature? (1)

Can you **edit** one file **while printing out** another? (1)

Are there **other** special **editing features** that appeal to you? (1½)

Subtotal for editing power:

Formatting power—25* points

[*With virtual representation, possible total of 30]

Can you vary:
the top and bottom **margins**? (—1 *if you can't*)
the side margins? (—1 if you can't)
character **spacing**? (1)
line spacing? (1)
the **tabs**? (½)
each tab setting individually? (½)
Are there decimal tabs? (½)
Are there automatic **indents**? (½) outdents? (¼)
Automatic **page numbering**? (1)
Can you choose:
where on the page the page numbers go? (½)
what text (if any) accompanies them? (¼)
Can you get **headers** and **footers** printed automatically on each page? (1)
Are there special features like horizontal scrolling to help with formatting **extra-wide text** or **tables**? (½)
Will the program allow you to **boldface** on printers that are capable of it? (¾)
Is there **overstriking**? (1)
Are there **subscripts**? (¼) superscripts? (¼)
Can you **underline** continuously, i.e., under spaces and punctuation as well as letters and numbers? (½) (—1 if program can't underline at all)
Can you automatically **center** lines? (¾)
Is there automatic **two-column printout**? (½)
Do you have a choice of **single-page or continuous** printout? (1)
Can you **link files** during printout, either by embedding a line at the end of each file or by specifying the files to be linked when you give the print command?
Either (1) Both (1½)
Can you have **multiple copies** of the same file printed out with one command? (½)
Can you embed a command that makes the printout **stop and wait** for your instructions? (¼)
Can you stop printout from the keyboard? (—2 if you can't)
Can you **print from** the **middle** of a file? (1)
Can you **justify** the **right margin**? (1)
Is there true **proportional spacing** on printers that allow for it? (2)
Is there **on-screen formatting**? (2)
(line breaks—½; page breaks—½; centering—½; other formatting information displayed—½)
[An extra 5 points is given for **virtual representation** (which is machine dependent). To qualify, the screen must display all of the following (partial points as indicated):
full page (at least 54 lines) of text (1)
underlining (½)
double underlining (½)
boldface (1)
justified right margins (1)
proportional spacing (1)]
Is there automatic **hyphenation**? (1)
If not, are there conditional hyphens? (½)
Is there a **conditional page break** feature? (1)
Can you ask for a no-break space? (¼)
Is there an **instant print** feature? (½)
Are there **other** special **formatting features** that appeal to you? (1½)

Subtotal for formatting power:

Responsiveness and support—4 points

(Based on reputation, users' comments, what the vendor says, etc.)

Program Name: Version #:
Operating system(s) it runs under and/or machine(s) it runs on:
Price: $
Publisher:
Vendor(s):
Overall score:
Scores in specific areas:
Safety and error handling (10):
Documentation (18):
Ease of use (18):
Editing power (25):
Formatting power (25*):
(*With virtual representation, a total of 30 is possible)
Publisher support (4):
Special notes: ■

Arthur Naiman is the author of several books on computers and is currently working on more. They include Introduction to WordStar *and* Computer Dictionary for Beginners.


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SPEED. PORTABILITY. RELIABILITY.

Reviewer's Notebook

by Rich Malloy

Last month I mentioned a few of the new printers we had received. This month I'll mention one more, plus another type of output device—a plotter. And we'll even cover some software for a change.

The HP 7475A

The arrival of the Hewlett-Packard HP 7475A plotter ties in nicely with *all* the attention that is being placed on the graphics capabilities of personal computers, especially in television commercials. In these commercials, all you have to do is press two keys and your complete financial picture appears in four or more colors. Nice, even if the number of keystrokes is vastly underestimated. But if you want to take your financial portrait around to your associates, you're going to need either a very good camera or a plotter. And you can't beat a plotter for resolution and speed.

The HP 7475A is the enhanced version of the popular HP 7470A plotter. The earlier version had only two pens and could handle only 8½- by 11-inch paper. But it was fast, accurate, and sold for the moderately inexpensive price of $1795. The new plotter sells for about the same price as the older one, but it has several superior features—six pens instead of two, the ability to handle larger paper (11 by 17 inches), a better character font (the letter "O" is actually curved rather than octagonal), and even automatic pen capping, which keeps pens from drying out.

Of course, these features would be useless if there weren't any software to take advantage of them. Fortunately, the people at Hewlett-Packard have been very successul at getting the major graphics software houses to write driver programs for the HP 7475A. At last count we had received more than 10 packages, including Lotus's 1-2-3, Supercalc3, and Graphtalk.

In typical HP tradition, the HP 7475A has more control keys than you could ever hope to become even vaguely familiar with, but it is an impressive little graphics machine nonetheless. We'll have a more detailed article on it in the future.

The MT-160 Printer

Getting back to printers, we should mention another of the printers being offered by Mannesmann Tally. The MT-160 is a real workhorse, though it may be one of the smallest office printers around. Priced at $795 ($695 without a near-letter-quality mode), the MT-160 is a fairly reasonable value considering its capabilities. It can print at 160 cps (characters per second) in draft mode and 80 cps in near-letter-quality mode. As for pitch, it can print at 10, 12, and 16.5 cpi (characters per inch), and it is the only printer I have seen lately that can also print at 20 cpi. For graphics it is compatible with the Epson. And it has both a serial and parallel port. To top things off, the MT-160 offers a unique and simple way to set its various parameters: you merely press a "yes" or "no" button in response to a series of questions it prints out. And it remembers this configuration even after you turn the machine off.

Friday! and Peachtext 5000

After all this talk about hardware, I should mention two software packages we've received for the IBM PC—one a database manager, the other a collection of practically everything.

The database manager, called simply Friday!, was announced last April by Ashton-Tate amidst tremendous hoopla. This easy-to-use application program written in dBase II was supposed to revolutionize offices. Practically anyone could use it to do practically any office task.

Now that Friday! has been out for a while, we must agree with some of the hype. Friday! is a good product. And while it is true that practically anyone can use it, there is a definite limit to what you can do with it. Two things are particularly objectionable. First, each field of data is limited to 32 characters. And although 98 percent of your data will fit in 32 characters, the 2 percent that doesn't will sure keep you from saying T.G.I.F. Second, although our IBM PC has 500K bytes of memory, Friday! acts as if it still has only 64. In order to use all of its 200K bytes of code, Friday! must constantly load small program modules from the disk drive and overlay them onto a 64K-byte memory space. Practically every other time we hit a key, Friday! goes out to the disk and pulls in another overlay. A nice product, but I'll wait for Saturday!

Another event that happened last April was that the folks at Peachtree Software decided to knock Wordstar off the Softsel software Hot List by offering Peachtext 5000, available for the IBM PC, the Compaq, the Texas Instruments Professional Computer, and the Zenith Z-100. It didn't knock Wordstar out of the Top Ten, but it's a real contender. It combines a good word processor with a thesaurus, a no-frills spelling checker, a no-frills spreadsheet, and a no-frills database manager, all for $395. Only the word processor and the thesaurus are real leaders in their field, and I have minor complaints about all of these programs. Also, these packages are not exactly "integrated" with each other. But you can't beat the price.

If you can afford to buy only five software packages for your MS-DOS machine, try just this one. If it doesn't meet all your needs, it *will* give you a good idea of what will. ■

ProDOS

by Rob Moore

Although Apple Computer's DOS 3.3 operating system has more software available for it than any other personal computer operating system, it does have some minor problems. Originally designed as an operating system for small floppy disks, DOS 3.3 doesn't easily support 8-inch floppy disks or the increasingly popular Winchester-technology hard-disk drives. Typically, vendors of larger disk drives have resorted to supplying DOS patches or special modified versions of DOS 3.3. Due to its heritage, DOS 3.3 also doesn't support very large files, or interrupts, which are necessary for local networking and other more advanced applications.

To remove these limitations, Apple is releasing ProDOS, a totally new operating system for Apple II and IIe computers. According to Bill Schjelderup, product marketing manager at Apple Computer Inc., ProDOS is "designed to overcome the limitations inherent in DOS 3.3 and provide a significantly improved base for applications software development." Although ProDOS doesn't make DOS 3.3 obsolete, Apple expects that most new applications will be written under ProDOS because of the numerous advantages it offers.

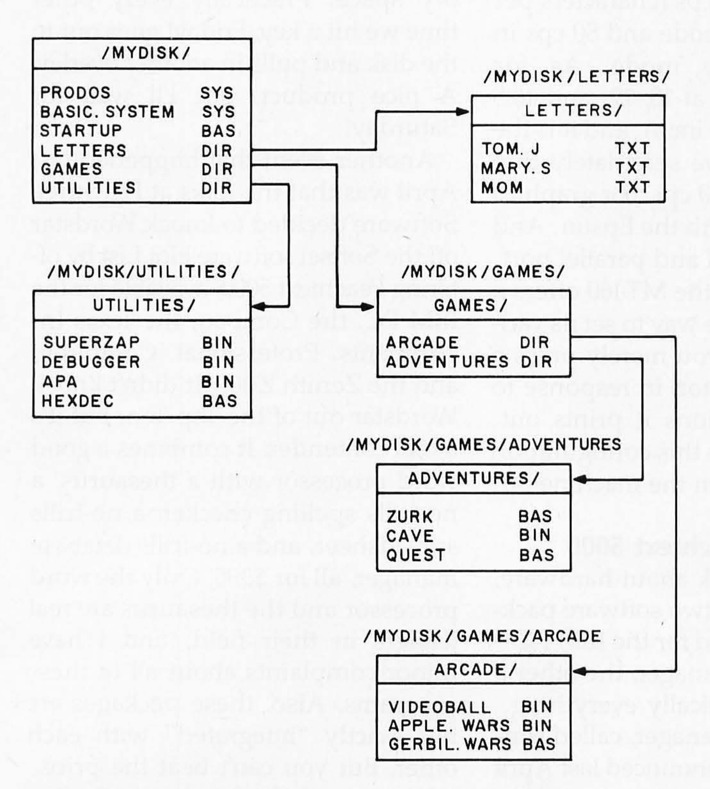


Figure 1: *A typical ProDOS directory structure. The pathname, shown above each directory listing, describes the path followed to reach a particular directory from the volume name on down. If the volume specified is mounted anywhere in the system, ProDOS will find it regardless of which drive it's in.*

New Features

ProDOS provides a variety of new features and greatly enhanced performance over DOS 3.3. Some of the new ProDOS features include

- support for Apple's Profile 5-megabyte Winchester hard-disk drive on an Apple II or IIe
- automatic time and date stamping through built-in drivers for the Thunderclock clock/calendar card (available from Thunderware Inc., 44 Hermosa Ave., Oakland, CA 94618, (415) 652-1737) or through user-installed drivers for other clock/calendar cards
- Unix-like nested directory structures and file types that are compatible with the Apple III SOS operating system so that disks can be interchanged between the two machines
- file sizes that can range from 1 byte to 16 megabytes, and the ability to randomly access any type of file
- up to 256 different types of files, including a number of reserved user-defined types
- support for up to four interrupting devices through user-installed interrupt handlers
- a uniform machine-language interface that lets assembly-language programs easily access and use all the ProDOS features
- use of Apple's 64K-byte extended 80-column text card as a high-speed pseudodisk for ultrafast file accesses

For the average user who programs primarily in BASIC, ProDOS adds a number of new commands and increases the flexibility of many existing DOS 3.3-type commands. In fact, the DOS command structure is *extensible*—ProDOS includes provisions for additional user-added commands to provide special features or allow customization for a particular application.

ProDOS is also much friendlier to outside peripheral vendors than DOS 3.3. ProDOS will automatically recognize and use other disk devices of all sizes, providing they are designed to follow the interface-protocol guidelines described in the *ProDOS Technical Reference Manual*.

For software developers, it will now be possible to

create one disk that will load on either the Apple II or Apple III. The boot loader, common to both ProDOS and SOS, recognizes the type of machine it boots on and attempts to load SOS into an Apple III or ProDOS into an Apple II or IIe. All you have to do is include both operating systems and the necessary files on the same disk.

Volumes, Directories, and Pathnames

A number of differences are found between ProDOS and existing operating systems like Apple's DOS 3.3 or Digital Research's CP/M. Where DOS 3.3 or CP/M specify disks by their *physical* drive location (e.g., S6,D1 for DOS 3.3 or B: for CP/M), ProDOS uses volume names to specify disks rather than the drive locations. Under DOS 3.3 or CP/M it's easy, for example, to delete the wrong file or initialize the wrong disk by inadvertently inserting the disk in the wrong drive. With ProDOS, errors like these don't occur. If ProDOS can't find the specified volume in a particular drive, it searches through all the drives attached to the system until the volume is found or the last drive is searched.

To help keep disk storage organized, ProDOS uses a Unix-like system of nested directories known as a hierarchical directory structure. In addition to having a main directory on each disk (or volume), ProDOS also allows subdirectory files within the main directory. Each subdirectory can hold files of any type, including further subdirectories. This nested directory structure makes it easy to keep large amounts of disk storage organized. (Figure 1 shows an example of a typical ProDOS user's disk directory structure.)

To specify which directory is accessed at any given time, ProDOS uses pathnames. A pathname describes the path to follow through the various levels of directories until you reach the directory where your program resides. For example, if you wanted to run a program called Videowars in a subdirectory called Games, which was in the main directory of a volume called Mydisk, you could type

RUN /Mydisk/Games/Videowars

To avoid having to retype the entire pathname every time you access a particular directory, ProDOS lets you set up a pathname prefix, which specifies a default directory. If you enter a pathname without a leading slash, it is automatically appended to the path stored in the pathname prefix, and the result is used as the actual pathname. Using the previous example, we could set the pathname prefix to /Mydisk/Games/ and then simply type RUN Videowars.

ProDOS's nested directories and pathname facility add some unique capabilities to your software. Programs can now keep their own directories and file types, avoiding some of the confusion encountered when all the programs on a disk are lumped into a single large directory. On a large hard disk, you can easily partition the disk into logical areas for various types of programs and data

At a Glance

Name
ProDOS

Type
Disk operating system software

Manufacturer
Apple Computer Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010

Hardware Required
Apple II or IIe computer with a minimum of 64K bytes of memory for operation with Applesoft BASIC; supports 128K-byte memory configuration with Apple's extended 80-column text card

Description
Single-user, single-task operating system with significant performance improvements over Apple's DOS 3.3; includes hierarchical directory structures, numerous predefined and user-definable file types, directory time and date stamping, support for up to four interrupts, file sizes up to 16 megabytes, and block-oriented disk I/O; ProDOS disks are compatible with Apple III SOS disks to allow easy file sharing between the two machines

Special Features
A 64K-byte column adapter card in the Apple IIe auxiliary slot can be used as a pseudodisk to provide significantly faster file accesses; ProDOS provides support for Apple's Profile 5-megabyte hard disk with the Apple IIe interface card

Software
Software utilities available for ProDOS include Filer, a program to initialize and copy whole disks or individual files; Convert, used to transfer files to or from DOS 3.3 disks; Exerciser, to access ProDOS machine-language calls and functions; BASIC.SYSTEM, a DOS command interpreter and user interface for Applesoft BASIC; and Help, which adds a series of help screens to the BASIC user interface; a BASIC Programming Examples disk can be used along with the ProDOS tutorial material in the documentation

Documentation
ProDOS User's Manual provides a tutorial on the Filer and Convert programs; **ProDOS Technical Reference Manual** describes internal organization, machine-language calls, organization of BASIC.SYSTEM, and how to interface additional device drivers and interrupt routines to the ProDOS system; **BASIC Programming with ProDOS** provides tutorial material and describes how to use ProDOS features and files from programs written in Applesoft BASIC

ProDOS Packages
ProDOS User's Manual with /Utilities disk including Filer and Convert
BASIC Programming with ProDOS with BASIC/Examples disk
ProDOS Technical Reference Manual with the Exerciser program on disk
ProDOS Tool Kit package includes 6502 macro assembler, text editor, and debugger with **6502 Assembler/ProDOS Tools Manual**
(The above packages were tentative at the time this article was written.)

Price and Availability
The price was not available at the time of writing; it is due to be released in early 1984 and shipped with new Disk II systems after that

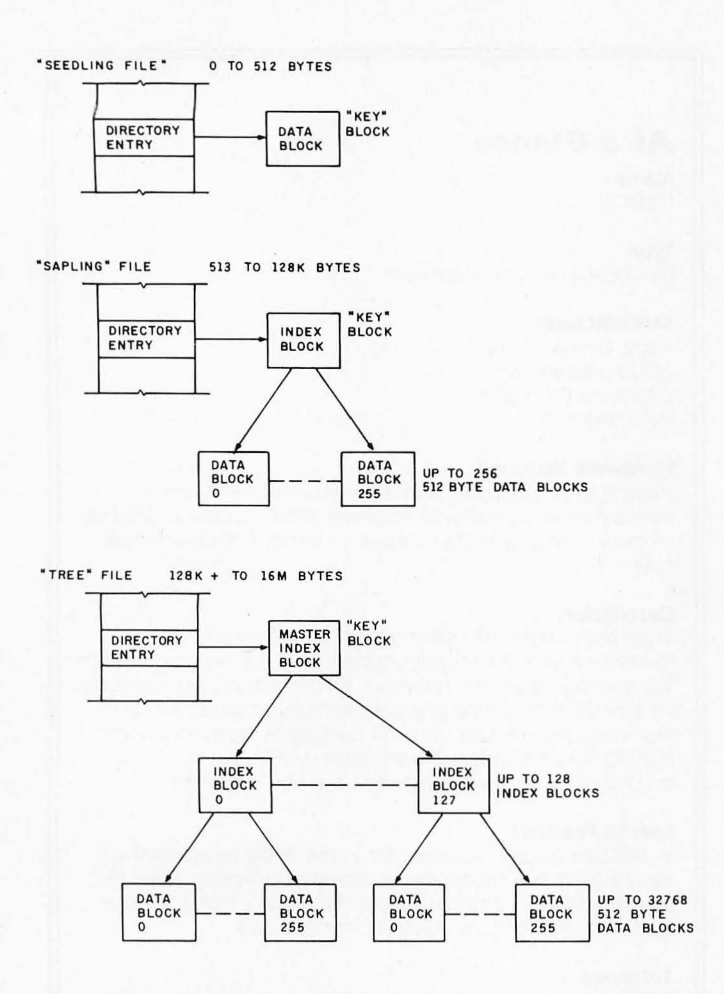


Figure 2: *ProDOS file-storage methods. ProDOS uses a growing "tree" structure to provide efficient storage of files that can range from 1 byte to 16 megabytes. Files smaller than 513 bytes are stored in a single data block and are referred to as "seedling" files. "Sapling" files have an index block that holds block numbers of up to 256 data blocks, thus providing storage for up to 64K bytes. The largest files, stored as "tree" files, use a master index block to designate up to 128 index blocks, each of which can point to 256 data blocks.*

As files grow or shrink during system operation, the file-storage method is automatically changed as the file size crosses the boundaries between "seedling," "sapling," and "tree" sizes.

files without having to resort to such tricks as making the hard disk look like a number of separate, fixed-size floppy disks.

Blocks and Files

Rather than dealing with physical disk tracks and sectors like DOS 3.3 does, ProDOS reads and writes 512-byte blocks. The conversion from disk sectors to blocks is handled by each disk's driver routines. For example, if ProDOS were reading a block from a disk that stored data in 128-byte sectors, the disk driver would read four sectors and supply the data to ProDOS as a single 512-byte block. Since ProDOS simply supplies a block number to the disk driver, it is completely independent of the physical disk-sector sizes or the number of sectors per disk track.

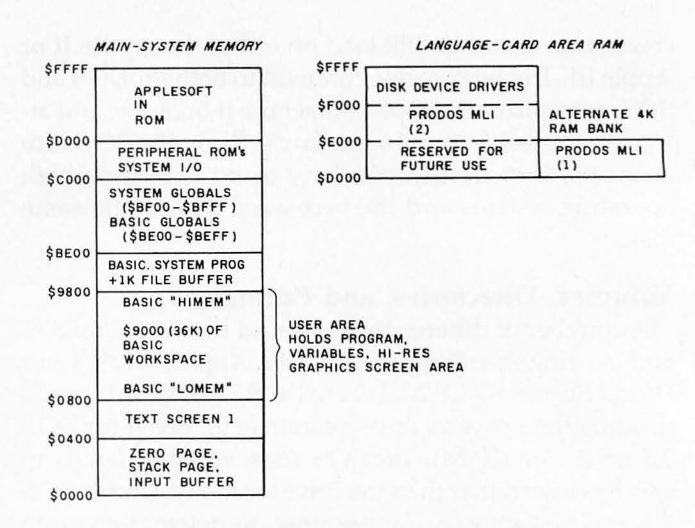


Figure 3: *A memory map of a 64K-byte Apple II or IIe with ProDOS and SYSTEM.BASIC installed. ProDOS is stored primarily in the language-card area of memory, and BASIC.SYSTEM resides in the area formerly occupied by DOS 3.3. Coincidentally, a ProDOS system provides about the same amount of free BASIC user space as a DOS 3.3 system.*

To efficiently accommodate files that can range from 1 byte to 16 megabytes, ProDOS stores files in three different ways (shown in figure 2). Depending on a file's size, it will be stored as either a "seedling" file, a "sapling" file, or a "tree" file. Files with sizes between 1 byte and 512 bytes are stored as seedling files—the data is stored in a single disk block. A sapling file can range in size from 513 bytes to 64K bytes. ProDOS creates an index block that holds the block numbers of up to 256 data blocks, each of which can store 512 bytes of data. Files larger than 64K bytes are stored as tree files that can consist of up to 32,768 data blocks or 16 megabytes of data. To store a tree file, ProDOS uses a master index block that holds the block numbers of up to 128 index blocks, each of which can specify 256 data blocks. As files grow or shrink during disk operations, ProDOS changes the storage method automatically—the entire process is completely transparent to the user.

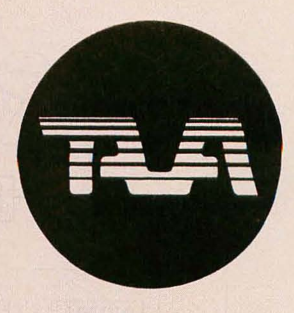
Inside ProDOS

From the BASIC user's point of view, many ProDOS commands are virtually identical to existing DOS 3.3 commands. However, ProDOS is a completely new design internally. It is normally located in the language-card area of memory and prevents the use of Apple's Integer BASIC that is loaded there, under DOS 3.3. (Figure 3 shows a memory map of a 64K-byte Apple II or IIe with ProDOS installed.) When used with assembly-language programs, ProDOS uses only the memory above hexadecimal BF00, leaving 45.75K bytes of free memory space in a 64K-byte machine.

Also unlike DOS 3.3, ProDOS doesn't include any user interface. All commands are passed to ProDOS through a set of 24 machine-language calls to the ProDOS MLI (machine-language interface), which are similar to the

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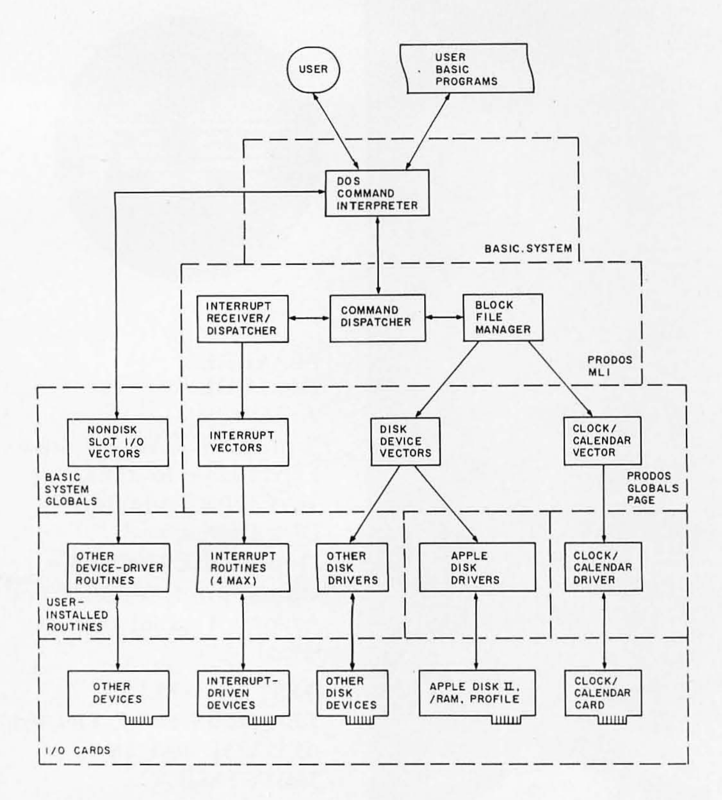


Figure 4: *A detailed block diagram of an Apple II or IIe with ProDOS and BASIC.SYSTEM installed. Arrows indicate the flow of control through the system. ProDOS includes device-driver routines for Apple's Disk II floppy-disk and Profile hard-disk drives. Also included are drivers to handle the /RAM pseudodisk and a Thunderclock clock/calendar card. Any other disk or clock/calendar devices require additional routines installed. Other interface cards with on-board ROM drivers will be recognized and operate properly, providing that they follow Apple's various interface guidelines.*

set of calls used by the Apple III's SOS operating system. No provision for user-entered commands exists within ProDOS itself. Instead, ProDOS is designed to work with various .SYSTEM programs, which translate user-entered commands into the appropriate ProDOS calls. (Figure 4 shows a block diagram of a typical BASIC user's ProDOS system.)

To maintain a consistent DOS interface while allowing Apple to alter the internal code in the future, ProDOS uses a 256-byte page of memory as a ProDOS globals page. The globals page is used to hold the addresses of all disk-driver routines, interrupt handlers, the clock-calendar routine (if installed), and the call address of ProDOS itself. It also holds a memory bit map that is used to indicate which pages of memory are currently used so ProDOS won't overwrite them during a load. The globals page is the only part of ProDOS that Apple guarantees will be consistent when future versions are released. No matter where ProDOS itself is loaded (depending on memory size), the globals page will always be in the same place and contain the same data. To allow programs to deal with future versions of ProDOS, the globals page also includes data to indicate the version of ProDOS currently installed in the machine and data to indicate the type of machine it's installed on. Currently, the system recognizes the Apple II series of computers or Apple IIIs running in Apple II emulation mode. However, room is available for future expansion.

Curiously, ProDOS won't work on most of the Apple II work-alikes. On a Franklin, for example, it hangs up during the boot process and coincidentally leaves Apple's copyright message on the screen. This is unfortunate for the owners of these machines, but you can't really expect the people at Apple to spend much time getting new software to work on unauthorized copies of its hardware.

BASIC.SYSTEM

Most users will talk to ProDOS through the .SYSTEM program called BASIC.SYSTEM, which provides an extended set of DOS 3.3-like commands to Applesoft BASIC. When BASIC.SYSTEM is loaded, it resides just beneath ProDOS in memory. Coincidentally, it leaves about the same amount of free memory as DOS 3.3.

Most BASIC.SYSTEM commands are compatible with the equivalent DOS 3.3 commands to allow existing BASIC programs to run with minimum alterations. A few seldom-used commands have been removed, however, and a number of new commands have been added and existing commands extended. You can now, for example, use OPEN, READ, WRITE, and CLOSE to access any type of file (including directories), and you can use BLOAD or BSAVE on any part of any type of file.

One of the most interesting new commands is simply a dash, a "run anything if possible" command. By typing " – filename", you can run a BASIC program, run a binary program, execute a text file of commands, or load and run a new .SYSTEM program.

To help you deal with ProDOS's nested directories, BASIC.SYSTEM provides a PREFIX command. You can use it to either set the pathname prefix to specify a default directory or to read back the current pathname prefix onto the screen or into a program variable.

BASIC.SYSTEM also provides I/O (input/output) commands that are much more flexible than those found in DOS 3.3. Instead of just using PR# or IN# to specify an I/O slot for input or output, BASIC.SYSTEM provides extensions to these commands that allow you to specify a particular address in memory to call for input or output or even to assign new addresses to given I/O slots. For instance, if your printer-interface card is in slot 1 and you have a special printer-driver routine loaded into hexadecimal address 300, you could type PR#1,A$300. From then on, any output normally sent to slot 1 would be sent to your routine at hexadecimal 300 instead. Another way to accomplish the same result would be to type PR# A$300 when you want to turn the printer on and PR#0 when you want to turn it off.

Adding Commands to BASIC.SYSTEM

In addition to providing a variety of flexible DOS commands, the BASIC.SYSTEM command structure is also extensible—you can add your own commands for special applications. By changing a pointer location *in*

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Listing 1: *A listing of the two benchmark programs used to perform the disk access-time tests for the 500-record file. The programs used for the Apple III and the IBM PC were similar. A 500-record file is created by the program in listing 1a and is read by the program in listing 1b (see "The Apple III and Its New Profile," September 1982 BYTE, page 92).*

(1a)

```
20 D$ =  CHR$ (4): REM  CNTRL-D
80 NR = 500
100  PRINT D$;"OPEN TEST"
110  PRINT D$;"READ TEST"
140  FOR I = 1 TO NR
160  INPUT B$
180  NEXT I
200  PRINT D$;"CLOSE TEST"
220  PRINT "DONE"
```

(1b)

```
20 D$ =  CHR$ (4): REM  CNTRL-D
40 A$ = "1234567812345678123456781123456 78"
60 B$ = A$ + A$ + A$ + A$
80 NR = 500
100  PRINT D$;"OPEN TEST"
110  PRINT D$;"WRITE TEST"
140  FOR I = 1 TO NR
160  PRINT B$
180  NEXT I
200  PRINT D$;"CLOSE TEST"
220  PRINT "DONE"
```

	Apple IIe ProDOS	Apple IIe DOS 3.3	Apple III SOS	IBM PC PC-DOS
Write 500 records	36	175	37	32
Read 500 records	35	221	33	23
Write 32K-byte file	19	44	—	—
Read 32K-byte file	5.5	31	—	—

Table 1: *A comparison of the relative floppy-disk access times of ProDOS and DOS 3.3 with times indicated in seconds. Times for the IBM PC and the Apple III are included for reference purposes. The 500-record file consisted of sequential 128-character records terminated with carriage returns, giving a total file size of just less than 64K bytes. (Benchmark programs used are shown in listing 1.) ProDOS appears to operate effectively six or seven times faster than DOS 3.3.*

the BASIC.SYSTEM globals page, you can specify the address of an external command routine, which will be called if BASIC.SYSTEM gets an unrecognized command.

Apple's Help and APA (Applesoft Programmer's Assistant) programs are two interesting examples of added BASIC.SYSTEM commands. Running the Help program on the /Examples disk adds a special HELP command to the system. You can then type HELP followed by any DOS command, and a screen of information describing that particular command will be quickly loaded from the Helpscreens file on the disk and displayed.

When you run APA, it adds a series of program editing and debugging commands. Some of the commands added by APA let you renumber your program lines, merge two BASIC programs, use automatic line numbering, hold a program in a special memory area, compress a program to remove all REM statements, and obtain an XREF (cross-reference) listing of variables versus line numbers.

Performance

According to Apple, DOS 3.3 transfers data to or from an Apple Disk II at about 1K bytes/sec while ProDOS transfers data at 8K bytes/sec. These figures are the raw transfer rates and do not include overhead time to access directories, open file buffers, or pass the data to Applesoft BASIC.

To evaluate the actual effective speed improvement, I used the same disk-access speed benchmarks used to evaluate the Apple III (see "The Apple III and Its New Profile," September 1982 BYTE, page 92). The evaluation included additional tests to write and read a 32K-byte file of binary data, simulating a large program store or load. (The benchmark programs used are shown in listing 1, and the test results are summarized in table 1.)

The performance increase with ProDOS was impressive. ProDOS ran five to six times as fast as DOS 3.3 when accessing text-file records or reading the 32K-byte binary file and about twice as fast when first storing the binary file. In fact, the times for ProDOS were almost the same as the times recorded for the Apple III running SOS, the progenitor of ProDOS.

It wasn't possible to use the same benchmark programs to measure the access times to the /RAM pseudodisk because /RAM provides 62K bytes of space while the benchmark program writes a 63.75K-byte file. However, the times to save and load the 32K-byte binary file were roughly 1.2 and 0.4 seconds respectively.

BYTE did not receive an Apple IIe Profile hard-disk drive for evaluation. However, based on the test results with the Apple III Profile, you should expect an additional improvement in overall disk speed of a factor of three to four.

Utility Software

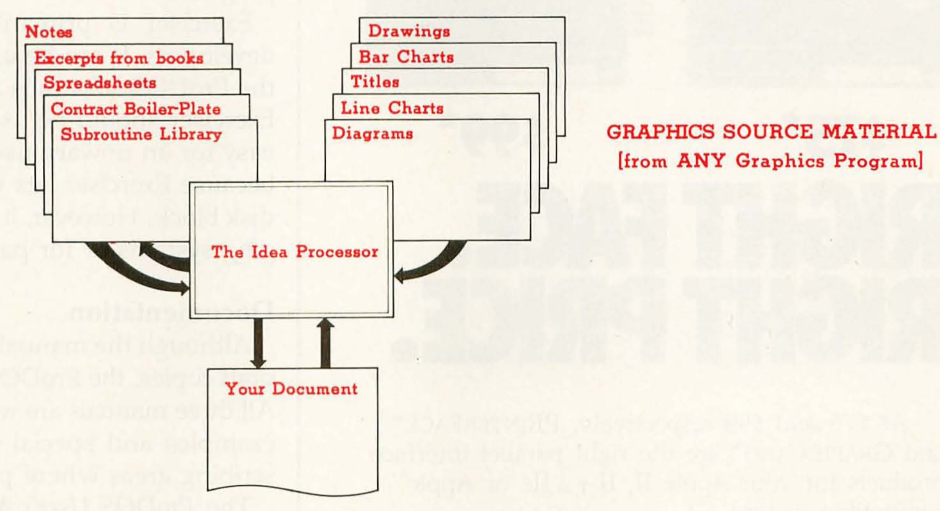
Along with ProDOS itself and BASIC.SYSTEM, Apple provides three utility programs: Filer, to manipulate disk files and volumes; Convert, to transfer files between ProDOS and DOS 3.3 format disks; and Exerciser, to access the ProDOS MLI commands.

Filer is used primarily to copy files or whole disks or to initialize new ProDOS disks, but it also provides options that let you delete or rename files, rename volumes, alter file write-protection, and list ProDOS directories. To help the novice user, Filer provides a series of built-in tutor screens that explain the various Filer commands and options. Filer is also useful when you're moving files from one directory to another on the same disk. You could, for example, create a new subdirectory called Games and then use Filer to copy all your game programs from the main directory to Games. If the name

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of each game program ended with the same suffix, the Filer wild-card character (=) could be used to accomplish the copy with a single Filer command.

Convert can be used to copy files in either direction between ProDOS and DOS 3.3. Since ProDOS uses different filenaming conventions than DOS 3.3 (filenames can be 15 characters long and cannot contain spaces), Convert modifies DOS 3.3 filenames by truncating them to 15 characters and changing any spaces to periods.

Both Filer and Convert appear to be well written and user-friendly. The prompting is clear and unambiguous—it will be difficult to make an error using either program.

Exerciser is primarily a tool for system program developers. It can be used to manually execute each of the ProDOS MLI calls and to modify areas of memory. Exerciser should be used with caution. It will be very easy for an unwary user to damage the data on a disk because Exerciser lets you read or write data onto *any* disk block. However, it should be invaluable for debugging systems or for patching a damaged disk.

Documentation

Although the manuals I received for review were early draft copies, the ProDOS documentation looks excellent. All three manuals are well written, containing numerous examples and special cautionary messages when describing areas where problems might occur.

The *ProDOS User's Manual* explains how to use the Filer and Convert utilities. Written at a level suitable for rank beginners, it takes you step by step through each Filer and Convert function, explaining any new term encountered along the way. I found the *ProDOS User's Manual* to be the least needed of the manuals supplied because both Filer and Convert are menu-driven and virtually bulletproof. You simply progress from menu to menu, selecting the options you want—it's almost impossible to make any serious mistakes.

BASIC Programming with ProDOS will probably be the most read of the ProDOS manuals. Even though much of the material included will already be familiar to DOS 3.3 users, it explains all the new ProDOS commands and options and includes descriptions of ProDOS directories, pathnames, and file types. For the beginner, *BASIC Programming with ProDOS* includes all the information necessary to learn to use ProDOS effectively. A large percentage of the manual is spent explaining text files. It includes chapters that describe how text files are created and accessed, how to use random-access files, and how to create files of commands as Exec files. The appendixes include descriptions of the differences between DOS 3.3 and ProDOS when using Applesoft BASIC, a summary of ProDOS commands and features, descriptions of all error messages, and a complete glossary of all terms used.

The *ProDOS Technical Reference Manual* provides a complete description of ProDOS's inner workings. It will be invaluable to anyone who wants to write a system program, install his or her own device drivers, or deal with

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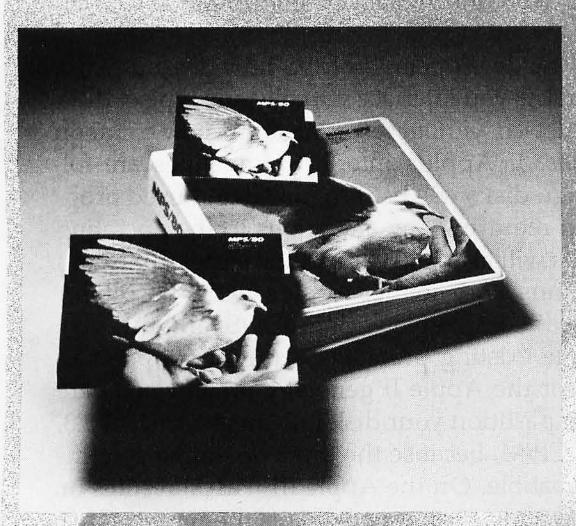
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ProDOS from assembly language. It includes chapters that describe files and pathnames, calls to the ProDOS MLI, writing system programs, and adding routines to ProDOS. Appendixes provide descriptions of the file-storage methods and directory formats, disk organization, the relationship between ProDOS and SOS, and how to use the Exerciser program.

ProDOS Packages

At the time this was written, Apple had tentative plans to market four different ProDOS packages. For assembly-language programmers, there will be a ProDOS Tool Kit with a new version of Apple's EDASM editor/assembler, a debugger program, and the *6502 Assembler/ProDOS Tools Manual*. The new version of EDASM includes macros and supports the various ProDOS file types and pathnames. Apple will also market a package that consists of the *ProDOS Technical Reference Manual* and the Exerciser program—useful if you want to write additional device drivers or .SYSTEM programs that interface directly to the ProDOS MLI. A BASIC users package will include *BASIC Programming with ProDOS* along with the BASIC /Examples disk. A utilities package will combine the *ProDOS User's Manual* with a /Utilities disk holding Filer and Convert.

Pricing hadn't been set when this article was written. Most previous Apple software packages of this type have cost less than $100.

Conclusions

ProDOS provides a significantly improved operating system for Apple II and IIe computers. With disk accesses about six times faster than DOS 3.3, files up to 16 megabytes long, and support for Apple's Profile 5-megabyte hard-disk drive, ProDOS provides an environment that will make it easier for applications developers to write the increasingly sophisticated software required by the business community. Using disk and file formats that are compatible with the Apple III's SOS operating system, ProDOS allows development of software that will boot up and run properly on either machine—loading ProDOS on Apple IIs or IIes and loading SOS on Apple IIIs.

For the more casual user, ProDOS may initially seem more complex to learn than DOS 3.3 due to its nested directory structure and increased command options. However, it will be easier to keep your programs organized under ProDOS, and the volume names and pathnames will prevent errors that could occur under DOS 3.3 if the wrong slot # or drive were specified. You should note that ProDOS does not make DOS 3.3 obsolete. There is no need to convert existing software to ProDOS unless you need the increased performance or new features.

For hardware developers, ProDOS provides a uniform protocol that lets you interface virtually any type of disk-like storage device without resorting to the now common DOS patches. If Apple's interface guidelines are followed, foreign disks will be recognized and used properly without requiring any alterations to the operating system. (This will also make life a little easier for users.)

On the minus side, neither Apple's UCSD Pascal nor Apple CP/M is compatible with ProDOS, and this may prolong some existing problems. Current suppliers of hard disks for the Apple II generally provide software that lets you partition your disk into areas for DOS 3.3, Pascal, and CP/M, because the three operating systems are not compatible. On the Apple III, Pascal resides on the SOS operating system and shares the nested directory/pathname facilities to manage disk storage. I hope to see a new Pascal for the Apple II with the same features. In the interim, Apple will supply software that will let you partition your Apple IIe Profile hard disk into separate areas for ProDOS and Apple's Pascal 1.1 operating system.

To summarize, Apple's new ProDOS represents a significant improvement over the existing DOS 3.3 operating system and includes features that are unavailable with most other personal computer operating systems. Although it may not be worth the effort to convert your existing DOS 3.3-based software to ProDOS, its capabilities give it some strong advantages for development of new programs.■

Rob Moore (Warner Hill Rd., RFD #5, Derry, NH 03038) is a design engineering manager with an interest in FORTH, graphics, and computer music.

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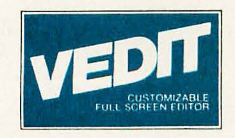
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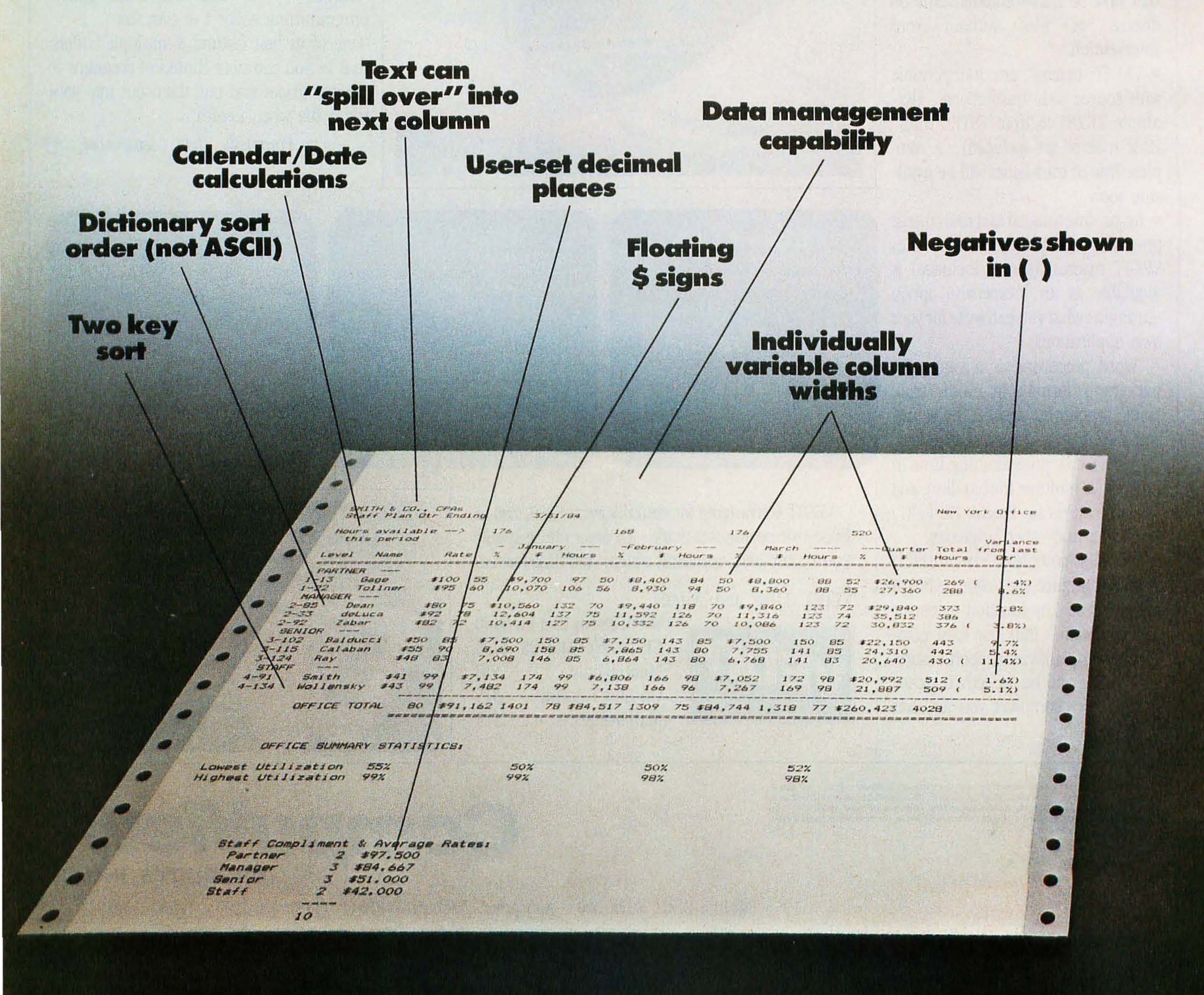
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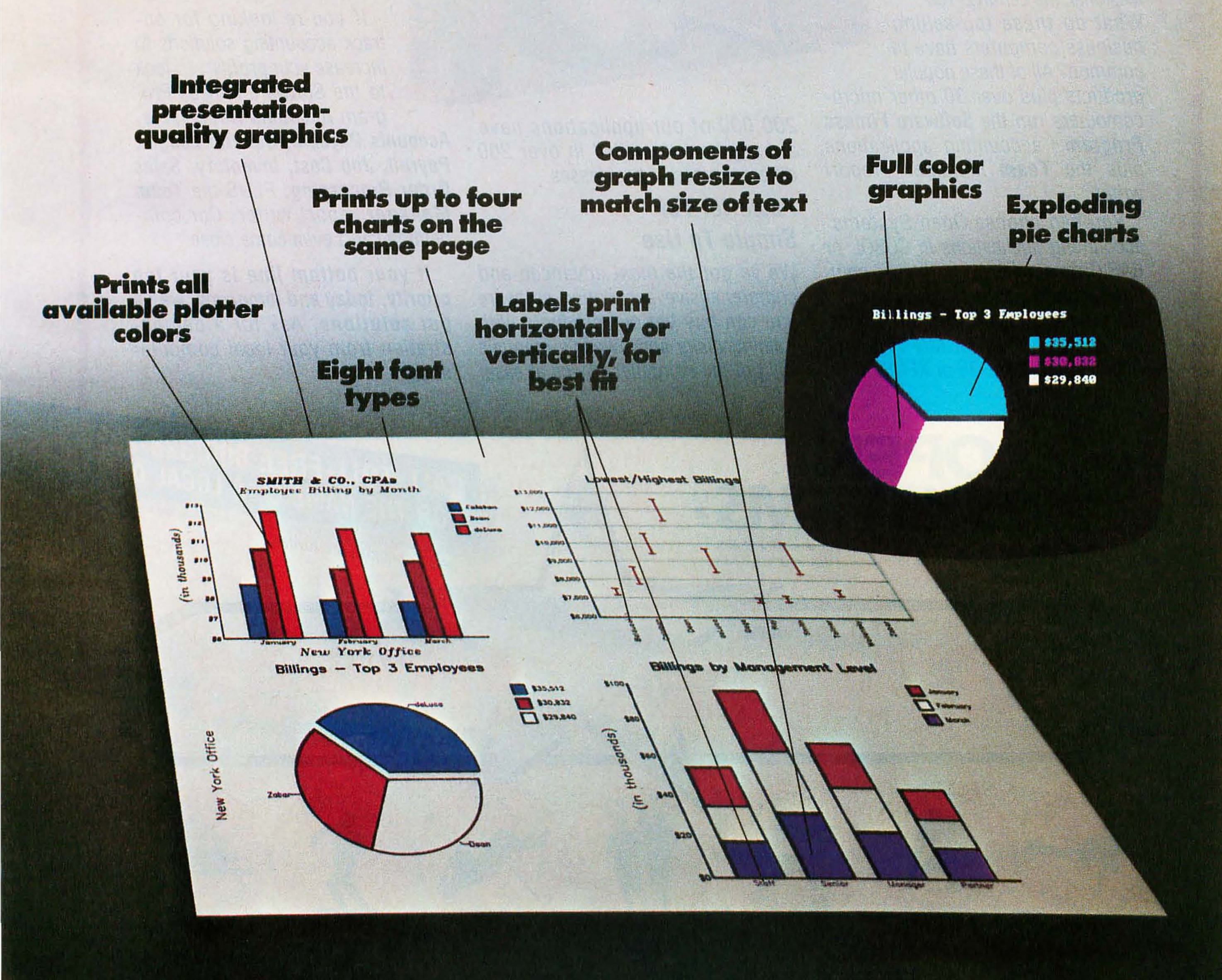
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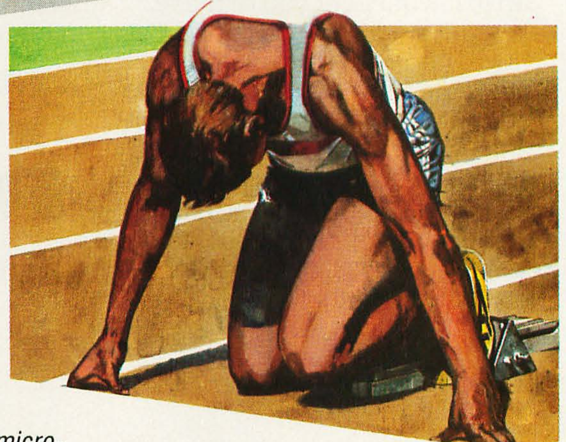
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Knowledgeman

A close look at a new, fully integrated management system with complete database and spreadsheet capabilities all in one

by James W. Walker

Multifunction integrated programs are a recent popular trend in personal computer software. These programs include such functions as database management, spreadsheet analysis, graphics generation, and word processing. Knowledgeman: The Knowledge Manager is a recent entry into this market.

This new information-management system from Micro Data Base Systems combines in one package a superior relational database-management system (DBMS), an advanced third-generation spreadsheet, a forms generator, the means for full statistical analysis, extensive operating functions, and a complete structured-programming language for writing command procedures. Both color and monochrome displays are supported. The program lists for $500 and requires a minimum of 192K bytes of RAM (random-access read/write memory). Recommended mass storage is 500K bytes. Knowledgeman takes full advantage of the new generation of 16-bit microcomputers with releases for the IBM PC, Victor/Sirius, and Altos microcomputers. Unlike most other relational database management systems, such as dBASE II or Condor, Knowledgeman has few design limitations. For example, with Knowledgeman you may have up to 255 fields per record and an unlimited number of tables open at once (assuming enough RAM and disk space are available), thus allowing multiple table processing with a single command.

My work involves determining the evolutionary relationships between groups of flowering plants. I use Knowledgeman to analyze the distribution of characteristics among flowering-plant groups. For example, if the pollen of cértain flowering plants indicates that two groups of plants may be related, Knowledgeman looks for other traits, such as flower, fruit, and seed type, that these groups may have in common. In this short review I can scarcely do justice to this comprehensive program, but I will attempt to outline its major features.

Database Management

As a database manager, Knowledgeman allows you to set up a file, define the various fields of each record, enter data, modify data, and access data in a number of different ways.

Table Formation

Knowledgeman creates each database as a table, consisting of rows, or records, and columns, or fields. The DEFINE command forms the table. You enter DEFINE and a table name, and the system prompts you for a filename and then for the fields. Each field must have a name and a type (string, numeric, or logical) and, if it's a string field, a maximum length.

You can have up to 65,535 records per table and up to 255 fields per record as long as you have enough disk space and RAM to handle it. Essentially, the software places no limit on record or field length since each may

At a Glance

Name
Knowledgeman

Type
Integrated relational database-management system and spreadsheet

Manufacturer
Micro Data Base Systems Inc.
POB 248
Lafayette, IN 47902
(317) 463-2581

Price
$500

Language
Assembly language and C

Format
Floppy disk

Software Required
PC-DOS 1.1 and 2.0, MS-DOS 1.x, or CP/M-86

Computer System
192K bytes of RAM, 500K bytes of mass storage

Documentation
One reference manual, beginner tutorial guide, fold-out command guide

Audience
"Second-time" users, BASIC programmers

be up to 65,535 characters long. You can define "pictures" to provide field-integrity checking (e.g., use placeholders to restrict data input to alphabetic, alphanumeric, or numeric characters) or specific kinds of editing (e.g., use placeholders to automatically convert alphabetic characters to uppercase or lowercase). Fields can also have fixed characters, e.g., the dashes in social security numbers can automatically occupy the proper positions on input. You can create virtual fields (defined by a formula) that occupy no storage in the table. The system updates virtual-field values as data changes occur in the fields or expressions that define them.

You can check table definitions with the SHOW command. SHOW with a specific table name gives you a display of the following: field names, field types, field "pictures," virtual-field definitions, index-key expressions, date of last modification, and current number of records. When SHOW is entered by itself, Knowledgeman gives you all tables in use and their complete filenames, as well as the default table.

The USE and FINISH commands respectively open and close the tables. If the RAM and disk space are available, there is no limit to the number of tables that can be used simultaneously. FINISH followed by a specific table name closes that table, while FINISH ALL closes all tables in use. A new default table can be declared using the DEFAULT command followed by the table name.

Data Input

After defining a table, you begin data entry with the CREATE command. Knowledgeman responds with "Record Number xxx" and provides field prompts. Fixed characters declared in field "pictures" appear automatically, and each field's length is indicated by dashes. The system supports full use of the IBM PC's arrow and special-function keys for editing data items (field variables). Field values of the previous record can be repeated. Furthermore, you can insert, delete, or overwrite a previous field-value display.

Knowledgeman doesn't provide virtual-field prompts because those values are automatically computed. If you create subsequent records after a table's initial record creation, you can place them in the file anywhere you choose.

Table Modification

You can easily modify tables with the REDEFINE command, adding new fields, deleting existing fields, or changing the type, size, or name of a field. You can redefine or add field "pictures" and virtual fields and rename or erase tables with the RENAME and DESTROY commands, respectively. Data items (field variables) themselves may be updated in one of two ways. Using the BROWSE command you can look at one record at a time and edit the data items in it or you can set the browsing scope to look only at records 134-256, for example. You can rapidly browse forward or backward through the records with the function keys. You can also set conditions, such as certain field values, for the records to be browsed. Knowledgeman has the added feature of selective field browsing so you can BROWSE (or CREATE) only some of a table's fields if you wish.

The CHANGE command changes data items globally. For example, the command CHANGE NAME TO "AUDREY" would change all field values for the field "Name" to "Audrey." However, if you want you can limit the scope of data item changes to certain record numbers or to certain conditions, e.g., you can CHANGE FNAME TO "AUDREY" FOR LNAME = "WALKER" to change only those records whose lname (last name) is "Walker."

Knowledgeman deletes records using a logical switch. When the system creates a record, it automatically sets up the first field as #MARK. You cannot delete or rename this field, and it has an initial logical value of "false." If you want to delete records, change the #MARK field of the selected records to "true" (with the MARK command). An UNMARK command is available to change records marked "true" back to "false." If you want to delete the records permanently, the COMPRESS command destroys all records marked "true." You can create new tables from existing tables using the IMPRESS, CONVERT, and ATTACH commands. The IMPRESS command allows you to "impress" an existing table definition onto a empty new table. Field names, types, sizes, and "pictures" are all carried over to the new table. The CONVERT command changes the field values from packed binary to a special file format—ASCII, BASIC-

compatible, and DIF (Data Interchange Format). If you only want the values from certain fields, Knowledgeman supports selective attaching. Although you can use the CONVERT and ATTACH commands in several ways, they are especially useful when you want to construct a new table out of existing tables.

Table Sorting and Indexing

The SORT and INDEX commands appropriately sort and index records. You can sort records in ascending (A-Z) or descending (Z-A) order or in some combination thereof. Sorting is based on the contents of a field or on relationships between fields (e.g., records could be sorted A-Z on three times the salary). You can also create indexes in ascending or descending order or in some combination of sequences using the INDEX command.

Data Retrieval

You can retrieve data a record at a time or generate an entire output table. There are two ways to get an individual record, OBTAIN and PLUCK. Use OBTAIN to get a particular record number, first, last, prior, or next

Perform files can keep the system busy for hours with just one entry.

record, as well as record number *xxx*, and to get a record conditionally, for example:

OBTAIN FOR FNAME = "AUDREY"

Use the PLUCK command for rapid retrieval of indexed records. This is the fastest way to retrieve a record conditionally, but before you can use the PLUCK command, you must create one or more index files for the table.

Knowledgeman uses B+ tree indexing for rapid record retrieval. You can use an unlimited number of index keys per table. Each index can have as many as 65,535 fields and be up to 65,535 characters long. If you want to conditionally retrieve records often, use index files; the PLUCK commands are much faster than the conditional OBTAIN commands.

The system can automatically update indexes as you make changes with the BROWSE and CHANGE commands. However, this slows down the CHANGE command significantly, so you may decide to override this feature and create new indexes after major table changes. You must recreate index files after using REDEFINE, COMPRESS, or SORT commands.

The SELECT (LIST) command creates a new output table from one or more existing tables. It is one of the most powerful Knowledgeman commands. You can pick any number of fields for data generation, and the order in which you list the fields determines the arrangement of the output table. You can SELECT to include, for example, all records, the next 100 records, or records in a

\BORDER	turn the spreadsheet's borders on or off
\BYE	leave spreadsheet mode while maintaining all spreadsheet definitions and variables
\COLUMN, \ROW	add or delete columns or rows
\COMBINE	combine portions of different spreadsheets
\COMPUTE	compute up-to-date values for all of a spreadsheet's cells
\CONCEAL, \REVEAL	conceal cell's definitions from view (or reveal to view)
\COPY	copy cell definitions
\DISPLAY	print desired cell values
\DUMP	print formulas serving as basis for cell values
\EDIT	edit the active cell's definition
\PROTECT, \UNPROTECT	protect or unprotect cell definitions from alterations
\SAVE, \LOAD	save or load a file
\STOP	leave spreadsheet mode without maintaining spreadsheet cell values
\STYLE, \ACTIVATE, \DEACTIVATE	declare and conditionally activate-deactivate reverse video, blinking, etc.
\UNDEFINE	undefine a cell or block of cells
\USING	assign a "picture" to a cell for integrity checking and editing
\WIDTH	specify the column width
\=	reposition the spreadsheet display

Table 1: *The Knowledgeman spreadsheet commands.*

certain range. You can specify "pictures" for output data values to edit the data or set up any number of conditions for data retrieval. A full set of logical operators is available, including =, <>, >, <, >=, and <=.

Knowledgeman allows an unlimited number of tables to be open at once (dependent only on available RAM and disk space), so you can use the SELECT command to query multiple tables. The system supports wild-card string, character-match symbols, and a "unique" qualifier to suppress the display of an item's next value if it equals the preceding one. You can SELECT dynamic, multifield, multisequence sorting of the output table with the qualifier

"ORDER BY direction fieldname. . ."

This enables you to obtain sorted data from only the records retrieved without having to physically sort all the table's records. Finally, you can have an unlimited number of changes in an output field's value triggering control breaks by using the qualifier

"GROUP BY fieldname. . ."

This computes full statistics for all the fields in each control break and displays them if you wish.

Spreadsheet

To use the Knowledgeman spreadsheet within the database program, enter the CALC command. Spreadsheets can have up to 255 rows or columns. Special effects include up to eight foreground or background col-

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ors, reverse video, blinking, half-intensity, and sounding the bell (provided your hardware can handle it). The spreadsheet has entry, edit, and message lines and variable column widths, and you can execute regular database commands within it. Some of the spreadsheet commands are listed in table 1. Notice that \BYE database commands can be executed within the spreadsheet mode. Equally important, spreadsheet cells can extract data from independent tables and can also be defined as programs.

Forms Generation

You can design forms for data entry or output with the FORM command, declaring any number of elements. Use an AT command to position labels or data values at the desired row-column. Display forms with the PUTFORM command and print or write them to disk (with or without data) with the PRINT command. The TALLY command uses a screen form for "what if" analyses comparable to spreadsheet analyses. Screen forms may have up to eight foreground or background colors, reverse video, blinking, half-intensity, and bell sounds. The CLEAR command followed by a form name clears the form from the screen; when used alone, it clears the entire screen.

Statistical Analysis

You can generate a full statistical analysis of the output table with the SELECT command or you can obtain the desired statistics without displaying field values using the STAT command. The following statistics are available for numeric fields: count, sum, mean, minimum, maximum, variance, and standard deviation. Numerical accuracy depends on the operating system and the central processor. Count and minimum-maximum statistics are available for string fields as well.

Operating Functions

Knowledgeman supports many operating functions, numeric, string, and logical. Numeric operating functions include absolute value, arcsine, current record number, exponentiation, string length, natural and base 10 logarithms, position of matching string values, maximum and minimum comparisons, random number generation, root computation, sine, and square root. String operating functions include uppercase and lowercase conversion, substring extraction, trailing blanks elimination, and type determination. You can use logical functions to determine if you have reached the end of a table, if a file is on line, or if a string's first character is alphabetic or numeric. These operating functions are particularly useful in command procedures.

Command Procedures

When the same list of commands must be performed two or more times, Knowledgeman allows creation of command procedures (one or more commands in a perform file). A perform file is basically a batch file that you can evoke within the Knowledgeman program. You can

create perform files with a word-processing program or by using the COPY CON: command at the PC-DOS system level. Perform files can contain an unlimited number of commands. This way, you can initiate enough commands to keep the computer busy for several hours while only having to enter one of them.

You can call a perform file from within Knowledgeman with the PERFORM command or by including the perform filename with the KMAN command at the system level. The lengths of Knowledgeman commands and command procedures are unlimited.

You can include comments within commands and command procedures, using "* " before and " *\" after the comment. A single command procedure can contain up to 26 different parameters and an unlimited number of working variables that are entirely unrelated to table fields or spreadsheet cells. Working variables, macros, and forms can all be declared local to a given procedure. There is also a complete structured-programming language to construct command procedures.

Program Design

Knowledgeman comes with a memory-resident 56K-byte main program and 16 overlay files that are called as needed. The overlay files run from about 8K bytes to nearly 17K bytes each (most are between 12K and 15K bytes). All 16 overlays together total slightly more than 210K bytes. For those with tight disk space it is possible to load the 56K-byte KMAN.EXE file that stays in memory and then use one drive for overlays and the other for data files. In addition, those with limited disk space can use several disks with different overlay programs on them. For example, if you are not using the spreadsheet mode you can leave out two overlays devoted exclusively to the spreadsheet, saving more than 30K bytes. Since the SORT, INDEX, CONVERT, and SELECT With Dynamic Sort commands generate temporary files on the default drive, it is useful to have one disk containing only the overlay files for default work space.

To enter Knowledgeman from the system level, key in KMAN. You can enter a perform filename to implement a particular set of environment variable definitions, macro and/or form declarations, and/or commands. For example, I call a perform file on entering Knowledgeman to set environment variables E.DMIN and E.DMAX to false (so the minimum and maximum statistics don't display with the SELECT command) and E.PAUS to true (so the system pauses after each screenful of data output).

Knowledgeman doesn't provide any menus, but you can easily create them with a word-processing program. Using Knowledgeman's structured-programming language and command perform files or a program like Prokey, it is not difficult to develop a menu-driven system. I started to do this but soon discovered that Knowledgeman's command structure is so easy that a menu-driven system is hardly necessary. I did use Prokey to define 40 special-function keys (F1-F10 unshifted, shifted, plus Control key, and plus Alternate key). I also used com-

Function	Command	Time
Nonconditional single-record retrieval	OBTAIN	<:02
Indexed single-record retrieval	PLUCK	<:02
Conditional middle-record (No. 672) retrieval	OBTAIN	1:24
Conditional last-record (No. 1345) retrieval	OBTAIN	2:48

Table 2: *The OBTAIN and PLUCK command performance test results. Times are shown in minutes:seconds.*

ments embedded in commands. This kind of command-driven system is much faster than a menu-driven one and still has many of its advantages.

Knowledgeman allows unlimited macro nesting and macros can be of any length. It also has a series of user-definable variables—environment variables and utility variables. Environment variables all begin with "E." followed by up to four letters; they have string, numeric, or logical (true or false) values. All environment variables have default values and are easily changed in Knowledgeman or a command-procedure file.

The environment variables do such things as control whether the bell sounds on input of invalid data, define which statistics are displayed with SELECT or STAT commands, and suppress error messages.

Utility variables are preceded by a "#" and can also be modified. They contain such things as the average, count, maximum, minimum, and standard deviation.

The SAVE command stores environment and utility variables, global working variables, global macro and form definitions, and current spreadsheet definitions. You can leave Knowledgeman, do something else, and then resume work where you left off. The LOAD command, which reloads this information, can operate in whole (loading everything) or in part (loading only macros, working variables, or forms, for example).

Knowledgeman provides extensive data security to be used or not at your discretion. A file named USRMAN.EXE creates a global user file called KPASS.IGU containing passwords and security levels. You can use USRMAN.EXE (62K bytes long) to authorize new users, delete users, alter a password, or change a security level. You can specify read/write authorization down to the individual field or cell level. There are 65,535 possible security-code combinations, data files are encrypted, and a 49K-byte scramble utility is provided to encrypt perform files so they cannot be read at the system level.

Performance

Written in assembly language and C with data files in condensed binary code (convertible to ASCII), Knowledgeman's performance is very pleasing. Limitations on the program's speed appear to be more the result of hardware restrictions than software restrictions. I ran command tests using two different data tables with the following results (both on an IBM PC with 320K bytes of RAM and two 320K-byte double-sided, double-density floppy-disk drives, using PC-DOS 1.10 and Knowledgeman 1.00).

The first series of commands were tested on a 154K-byte data table with 19 fields and 1345 100-character records (see table 2). The results suggest that you should prepare indexes for fields you intend to retrieve often while you use the conditional OBTAIN command only when you want a field seldom used as a key.

I also performed various tests of the SELECT (LIST) command for this first data table. The results are shown in table 3.

A second data table, 152K bytes long, with 47 fields, and consisting of 592 208-character records, was also tested. Results are shown in table 4.

The small difference between the time for a conditional SELECT on four conditions with a dynamic sort (3:36) and the time for the same command without the dynamic sort (3:32) proves how fast the sorting process is and suggests that the response time is largely disk dependent.

I am pleased with Knowledgeman's speed, especially the SELECT command. Hardware seems to be the greatest limiting factor in this program's performance. The following suggestions may help overcome some of these limitations. First, try a hard disk rather than a floppy disk. Knowledgeman is not copy-protected, so you can put it on a hard disk or a RAM disk. Getting enough RAM to hold frequently accessed files should also improve performance because the system spends so much time searching the current database table.

Documentation

The 300-page reference manual (including appendixes) contains 12 chapters, 7 appendixes, a glossary, an index

List data values for five fields	Time
Nonconditional SELECT	<:03
Conditional SELECT (single condition)	3:13
Including dynamic sorting:	
Nonconditional SELECT	
Sorted on one field	4:03
Sorted on five fields	7:41
Conditional SELECT (single condition)	
Sorted on one field	3:01
Sorted on five fields	3:19

Table 3: *The first SELECT (LIST) command performance test results. Times are shown in minutes:seconds.*

List data values for seven fields	Time
Nonconditional SELECT	<:03
Conditional SELECT (single condition)	2:50
Conditional SELECT (four conditions)	3:32
Including dynamic sorting:	
Nonconditional SELECT	
Sorted on one field	3:07
Sorted on five fields	4:32
Conditional SELECT (four conditions)	
Sorted on five fields	3:36

Table 4: *The second SELECT (LIST) command performance test results. Times are shown in minutes:seconds.*

of commands, and a general index. The manual is written for three levels of comprehension: introductory, intermediate, and advanced, and sections are marked accordingly so you can reference it at the appropriate level of knowledge.

User Support

Micro Data Base Systems provides a customer-support number for end users. The people I spoke to were knowledgeable and courteous, returned my phone calls promptly, and answered all questions to my satisfaction. They will send one free update of Knowledgeman to everyone who sends in the program registration card, if a new update exists at the time the registration card is sent. A complete copy of the revised reference manual comes with the update.

Defects and Suggested Improvements

I found only one major problem in version 1.00 of Knowledgeman after using the database part of the program extensively. Micro Data Base Systems promised to fix the bug in the next release, and, sure enough, when I received it, the problem was gone. Considering the size and complexity of the programs involved and that this was version 1.00, I find Knowledgeman remarkably error free.

Although the list of Knowledgeman's features is impressive, there is always a "wish list" of useful additions: for instance, it would be nice if you could display or print using field names (i.e., labels could be longer than the length of their field variables), if the SHOW command were separate from the ATTACH-IMPRESS overlay file (why should you need a 17K-byte overlay file to call the table directory command?), and if you could use wildcard characters in any expression (even if that limits their use), instead of having to use the IN operator.

Conclusion

Knowledgeman is an integrated information-management system combining a superb relational database with a fine spreadsheet for the price of one. You get a printed forms generator, screen-form management, statistical analysis, many operating functions, and a structured-programming language for building command procedures. More Knowledgeman modules are coming, including a graphics generator, an integrated full-screen text editor, and a forms "painting" feature. Knowledgeman activities and materials, including training seminars, videocassettes, a pocket-sized command guide, and a beginners' tutorial manual, are being developed rapidly. QUE is publishing an applications book, *Using Knowledgeman*, in the near future.

It is my opinion that Knowledgeman may be the most powerful relational DBMS currently available for microcomputers. For example, dBASE II allows only 32 fields per record, a maximum of two tables open at once, and no dynamic output sorting. Knowledgeman, on the other hand, allows up to 255 fields per record, an unlimited number of tables open at once, and dynamic output sorting. In addition, Knowledgeman is an integrated program, combining spreadsheet capabilities with database management.

Unlike Lotus 1-2-3, basically a spreadsheet-graphics generator with limited database capabilities, Knowledgeman is a full-fledged, powerful DBMS fully integrated with a full-fledged spreadsheet (with graphics coming). Lotus 1-2-3's limited "spreadsheet-used-as-a-database" has a maximum of 2048 records per table with only one table open at a time (hence no multiple table query). Knowledgeman allows 65,535 records per table and an unlimited number of tables open simultaneously. Moreover, Lotus 1-2-3's spreadsheet doesn't let cells access independent database tables or contain entire programs as Knowledgeman does. After several months use, I have learned to appreciate a statement made in the reference manual introduction: Knowledgeman has been "carefully designed to dominate all of the leading file handlers, 'application generators' and 'relational' systems existing in the micro world." Micro Data Base Systems can be proud of this package, its creation, and its continuing development.■

James W. Walker (Department of Botany, University of Massachusetts, Amherst, MA 01003) is a professor of botany researching pollen ultrastructure and the evolutionary relationships of flowering plants. He considers his computer an indispensable tool in his research. (Work supported by NSF grants DEB 80-10893 and BSR 82-09195.)



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The IBM CS-9000 Lab Computer

A closer look at IBM's "other" microcomputer

by Thomas R. Clune

At the Brandeis University Chemistry Department, we have been trying to use the IBM Personal Computer (PC) for all our microcomputer applications. Most of the time, we have been able to meet our needs with the PC. But not always.

Here's a case in point. One of our researchers wanted to have a microcomputer pulse a laser, trigger data collection on a Biomation 8100 waveform digitizer, then download the 2K bytes of data from the Biomation into the computer. This process would be repeated up to 1000 times at a rate of 30 times per second. The result of each run would be summed with the results of the previous runs. Next, a stepper motor controlling a monochrometer would be incremented, and all of the above would be repeated again for up to 200 monochrometer settings.

There was one more requirement—the computer should cost no more than $10,000. That's a lot to ask. Surprisingly, though, it can be done, and done well, with the IBM CS-9000.

At the time I encountered this problem, the IBM Instruments Division in Danbury, Connecticut, had just announced its 68000-based laboratory computer, the CS-9000 (see photo 1). Usually, I prefer to wait until a product has been on the market for a year or so before using it. This gives time for the new-product hoopla to subside, the groundswell of early-user complaints to crest, and the manufacturer to show its level of good faith in correcting bugs. But we were faced with a Hobson's choice: either the CS-9000 would be adequate for our needs or nothing in our price range was. So, after a trip to Danbury to see the operation of a prototype, we took the plunge. For those who can't wait for an ending, we found two things: (1) being the first on your block is even more painful than we had expected, and (2) the CS-9000 is an incredibly powerful computer.

A System Description

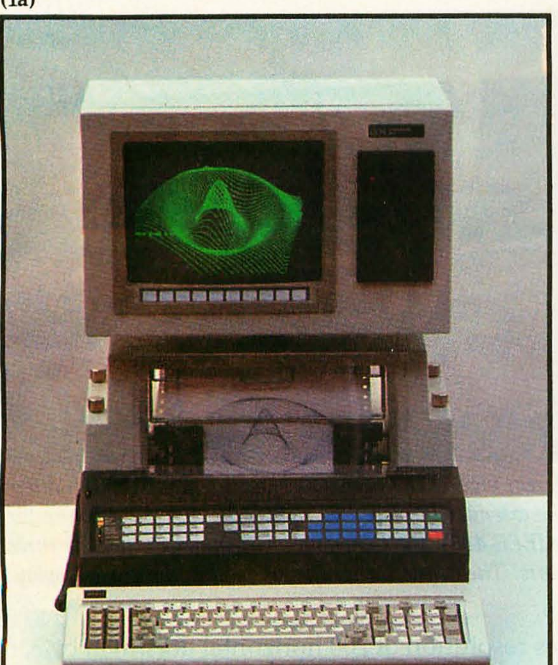
The IBM CS-9000 is so versatile that it would take years for one person to test all of its features (see the January 1983 BYTE, page 100, for a product description). I am most familiar with a subset of the system's capabilities. In this review, then, I will describe the CS-9000's major features in broad strokes and give in-depth coverage of those aspects with which I have personal experience.

If you want additional information on the rest of the system, talk to IBM. In my experience, the people there are very helpful and scrupulously accurate in their discussion of the CS-9000. Indeed, the single strongest point of this generally excellent system is the unbelievable level of customer support. In particular, Dr. John Tesch of the customer-service department has provided us with expert technical assistance, the cash value of which has probably exceeded the purchase price of the system.

Now, for the computer itself. The basic processor unit features include

- an 8-MHz Motorola MC68000 16/32-bit microprocessor
- three cascadable, 16-bit timers for up to 2-MHz clocking
- 128K bytes of on-board RAM (random-access read/write memory)
- 128K bytes of ROM (read-only memory), for a real-time operating system
- SYSBUS (a superset of Versabus) bus structure
- five expansion slots
- four DMA (direct memory access) channels with 1-MHz maximum throughput
- seven levels of interrupt
- one IEEE-488 parallel bus (see photo 2)
- three RS-232C serial ports (see photo 2)
- one bidirectional, 8-bit parallel port (see photo 2),

(1a)



(1b)

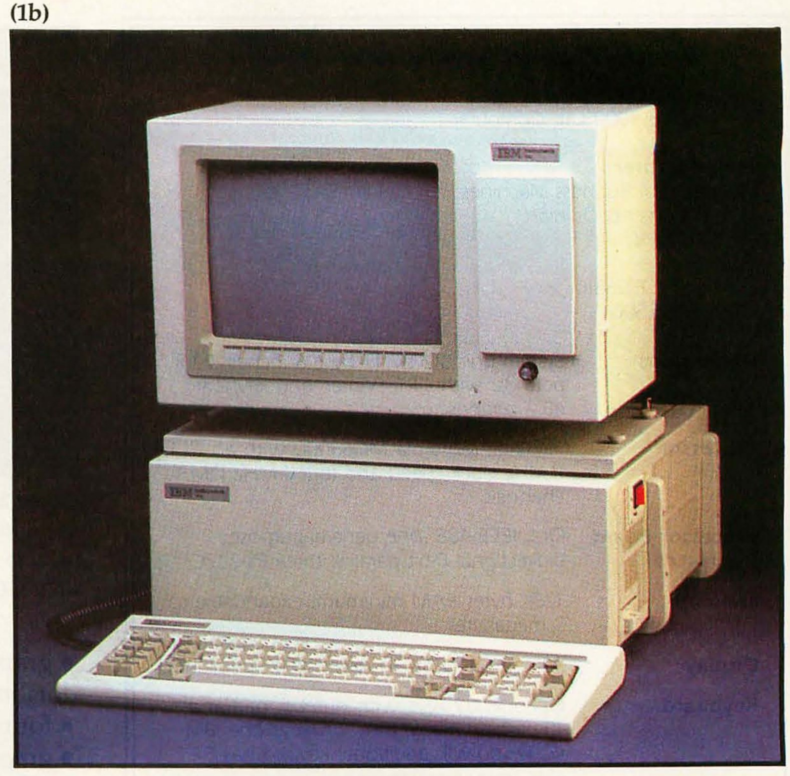


Photo 1: *At left (1a) is a front view of a typically configured IBM CS-9000 with the built-in dot-matrix printer. The rectangular plate covers a mount for a single 5¼-inch floppy disk. Notice the paper tray under the keyboard. The handle below the video display connects to the mounting yoke (see text). Photo 1b shows a front view of the business configuration of the CS-9000. Note that the built-in printer and softkeys have been removed.*

which is not a true Centronics-type port because it lacks some lines (e.g., BUSY and DONE); however, any device supporting a Centronics-compatible interface can be connected to it

- 57 pressure-sensitive keys for dedicated systems control (see photo 3)

The monochrome display (see photo 4) shows 80 characters by 30 lines of text and has fairly good graphics resolution (768 by 480 pixels). This seems a bit thin for computer-aided design (CAD), but IBM has sold a number of the CS-9000s for preliminary design work-ups. The display has its own separate memory and 10 programmable softkeys. It also includes space for a single 5¼-inch floppy-disk drive.

The minimal configuration just described is used with the ROM-based operating system. Disk-based software is available for data acquisition and process control of the IBM Instruments Division's line of chemical instruments. These include FTIR (Fourier transform infrared spectrophotometry), NMR (nuclear magnetic resonance), and HPLC (high-performance liquid chromatography) analyzers. In connection with the HPLC, IBM offers a four-channel, 13-bit, 30-Hz ADC (analog-to-digital converter) card called the sensor board. The card provides autoranging with a dynamic range of 10^6. Also included on the sensor board are four more RS-232C ports, 32 bits of parallel I/O (input/output), eight LED (light-emitting diode) drivers with eight debounced-switch inputs, and two 16-bit counters. IBM does not currently offer a high-speed ADC; however, the company tells me that it considers this a requirement for the near future.

To make the unit a usable computer, you will need to add a system bus card with five expansion slots and at least another 256K bytes of RAM on the expansion card. Each memory-expansion card can hold up to 1 megabyte of RAM, for an on-board system maximum of 5 megabytes. You will also need floppy-disk drives; the system supports up to four 8-inch and 5¼-inch drives in any combination. A hard disk, requiring a separate controller card, is also available. Next, you will need a keyboard; the keyboard offered with the system is the same one as on the IBM PC.

Additionally, you will need an extended, disk-based operating system. Two are available: Xenix and OS 1.1, a multitasking operating system with a full-screen editor that is similar to PC-DOS 2.0. The available languages include a BASIC interpreter, an assembler (included with OS 1.1), a FORTRAN compiler, and a Pascal compiler. A C compiler and a COBOL compiler (Xenix only) are reportedly in the works.

IBM also offers a dot-matrix printer that sits in the main processor housing and features

- software-selectable character density of 10 characters per inch (cpi), 80 characters per line (cpl); 12 cpi, 96 cpl; or 16.8 cpi, 132 cpl
- 24- by 9-dots/character matrix

At a Glance

Name
The IBM CS-9000 Lab Computer

Manufacturer
International Business Machines
IBM Instruments Division
Orchard Park
POB 332
Danbury, CT 06810
(203) 796-2500

Dimensions	System unit: 22 by 17 by 6.6 inches, 27.3 pounds; with CRT, printer, and keyboard, 68.2 pounds
Processor	16/32-bit Motorola MC68000 with an 8-MHz clock speed and four 1-MHz DMA channels
Processor Board Interfaces	One IEEE-488; one general-purpose, bidirectional 8-bit parallel; three RS-232C
Memory	128K bytes RAM minimum, expandable to 5 megabytes
Display	80 characters by 30 rows; green phosphor
Keyboard	Optional 83 keys with number pad and 10 programmable function keys (the IBM PC keyboard); additional keypad has 57 user-programmable keys
Mass Storage	Optional, 5¼-inch floppy-disk drives (327K storage); 8-inch drives (985K storage); 5¼-inch Winchester hard disks (5 to 10 megabytes of storage)
Expansion	Optional, five slots with a system bus card
Operating System	OS version 1.1; Xenix available soon
Languages	BASIC interpreter, 68000 assembler, FORTRAN compiler, Pascal compiler, and C compiler available (COBOL available with Xenix)

Software Options
Chromatography application program, math/stat library, IBM 3101 (and 3270 soon) emulator programs

Other Hardware Options
Analog/sensor card with four-channel, differential input; autoranging ADCs giving 12-bit plus sign resolution at 30 Hz; sensor board also has eight debounced switch inputs; eight output drivers to 5-V supply; 32 bits of parallel I/O assignable in 8-bit groups as input or output or as two 8-bit bidirectional ports; two cascadable 2-MHz clock counters providing two pulse trigger output points and pulse-counting input points; four asynchronous terminal or modem RS-232C ports with maximum speed of 19.2 bps; an adaptor to Multibus is available from Hal-Versa Engineering Inc., 18597 Paseo Tierra, Saratoga, CA 95070, (408) 374-2953

Documentation
8½- by 11-inch loose-leaf binder format; Operator's Manual, 108 pages; OS 1.1, 400 pages; Problem Isolation Manual, 114 pages; BASIC Manual, 500 pages

Price
Base system, $5695; printer, $2095; keyboard, $270; 256K-byte RAM expansion, $1095; 1-megabyte RAM expansion, $4080; dual 5¼-inch floppy disks, $1445; dual 8-inch floppy disks, $2470; hard-disk controller, $1295; single 5-megabyte hard disk, $2495; single 10-megabyte hard disk, $2695; expansion feature with five slots, $95; analog sensor board, $850; BASIC interpreter, $195; OS 1.1 extensions, $155; Pascal compiler, $595; FORTRAN compiler, $595; chromatography application program, $495

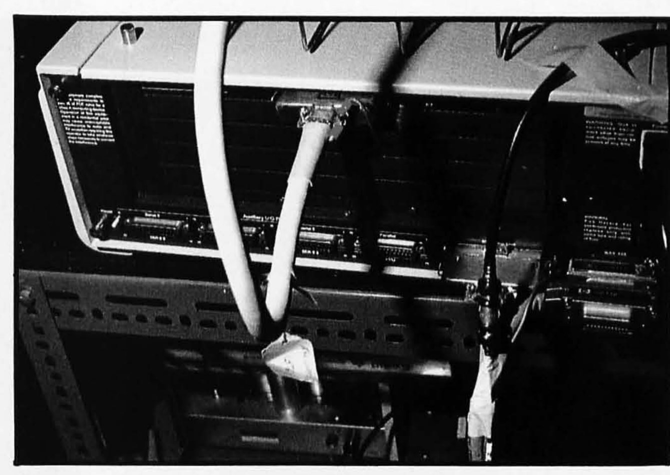


Photo 2: *A rear view of the CS-9000, showing the IEEE-488 interface with the extender in place (far right), the disk-drive connector (next to the IEEE-488), the Centronics port (middle), and the three RS-232C ports. The connector on the top goes to the video display.*

- graphics resolution of 200 horizontal dots/inch by 336 dots/inch
- four-color printing
- graphics and text screen dumps with the familiar shift-PrtSc keystrokes of the PC

The compact packaging of the CS-9000 is designed to save valuable laboratory bench space. We have set the unit on a four-wheel cart to roll it into position when it is being used and wheel it out of the way when it is not. The compact design is a mixed blessing, though. Because it is mounted on top of the computer and has to have adequate clearance for the printer beneath it, the screen is above normal eye level. Although the tilt of the screen is adjustable, the height is not. As a result, the operator tends to sit slumped in a chair with the keyboard on his lap and his feet on a desk, staring up at the screen. In short, the ergonomics of the package design are not state of the art. In a laboratory, however, you do not usually spend a lot of time at the keyboard. The working conditions of a researcher are not those of a secretary. For our applications, there have been no complaints regarding the display's human engineering.

If your applications are more keyboard-intensive, relief is at hand. The National Accounts Division and National Marketing Division of IBM have developed an interest in the CS-9000 for business applications. The system is being repackaged for them, sans integral printer, and given a quieter fan. The current fan sounds like a household vacuum cleaner. The business package is shown in photo 1b. The ergonomics, as you can see, are much improved. Because of the newfound business interest and the resultant expanded user base, a greater variety of canned programs should become available for this system. Indeed, the decision to offer Xenix and COBOL appears to be the first fruit of that interest.

Documentation

The documentation for the system is hardly a masterpiece. In fairness, it has been improved tremendously

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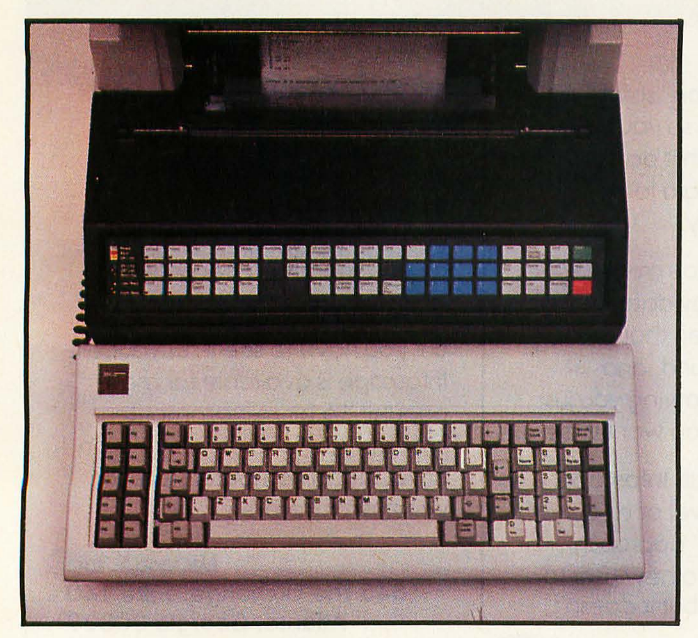


Photo 3: *The CS-9000 keyboards. At the top, on the front of the main processor box, are the 57 programmable, pressure-sensitive keys.*

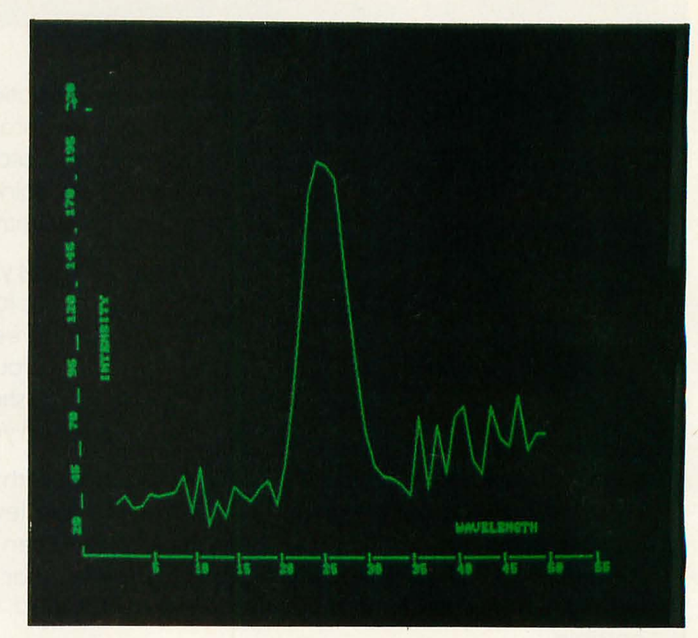


Photo 4: *A sample screen display that shows text and graphics, taken from an IBM demonstration program.*

since its earlier incarnations, but it is still less than ideal. The writing style is the usual turgid documentation prose. If you are a systems programmer it should present no great problems, but for a scientist-hacker it is formidable.

The manual lacks tutorials and, except for the high-level language sections, lacks indexes. Most surprising, the documentation does not contain schematics or a memory map. IBM has answered all questions promptly, but better documentation would lessen the number of questions users would have to ask.

The Voice of Experience

My experience with the CS-9000 began with setting it up. The bridge over the main processor housing, used to support the video display, is a pain to install. But it needs to be done only once, so what the heck. The video display mounts on a plastic yoke with a ball joint that enables the screen to be positioned for user comfort. Unfortunately, the yoke is made of very cheap plastic. When I went to tighten the yoke, I broke it, even though I followed the instructions to tighten gently. That yoke is cheap. I would have written this off to my superior strength, but another research group at Brandeis has a CS-9000 and the same thing happened to them. I have been informed that the yoke has been redesigned to eliminate this problem.

Once the system was assembled, I started to plug a digital multimeter (DMM) into the IEEE-488 port. It wouldn't plug in. Amazingly, the IEEE-488 port is positioned too close to the plug for the disk drive. There is no room for the IEEE-488 cord, which exits the plug from the side of the plug head. In order to use the IEEE-488 while the disk drive was attached to the system, I had to install an extender to the IEEE-488 interface (see photo 2). IBM now supplies the extender with the computer and will soon flip the IEEE-488 port upside down so that the cord does not interfere with the other plugs. You may not have to contend with this problem, but I was beginning to think I had made a very serious mistake.

It got worse. When the extension to the IEEE-488 plug was installed, I tried to write a BASIC program to transfer data from the DMM. Nothing. A call to IBM identified the problem: the software driver for the IEEE-488 was not yet written. After the driver arrived, I appended it to the BASIC program and tried again. Nothing. Another call to IBM. Dr. Tesch made the first of three trips to Brandeis. The problem was that we had a prerelease version of the operating system, but the software driver was for version 1 of it. He took the computer back to Danbury with him, had the new ROM BIOS (basic I/O system) installed, and sent the system back with the new 1.0 DOS (disk operating system) extensions disk. Nothing. More telephone calls. It turned out that we had the prerelease version of BASIC. After we got the right BASIC, the interface worked perfectly. By the way, the resistor in question was 56K ohms.

Next, all we had to do was get the Biomation, with a two-line handshake, to transfer data over the IEEE-488, which has a three-line handshake. I had an idea on how to achieve this and it looked fairly simple on paper. A few months later, it worked.

The next problem was writing an assembly-language program to do the data-acquisition routine. I am a complete *patzer* when it comes to assembly language. I usually write the program in BASIC, compile it, and then optimize the program by keeping intermediate values in registers instead of shuffling them back and forth in storage. But there is no BASIC compiler for the CS-9000. So Tesch (God love him!) agreed to write an assembly-language routine from my BASIC program. These people take "customer support" literally.

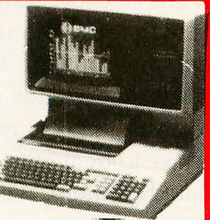
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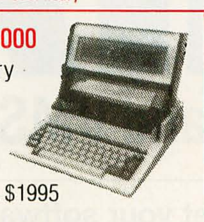
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Tesch wrote the program. Nothing. He didn't have a Biomation in Danbury to test the program, so he came back up to Brandeis to see what the problem was (this was the third time; I've shortened the story a bit). He managed to identify the errant line of code, and we were finally squared away. While he was at Brandeis, he provided us with three different versions of the data-acquisition routine for three different modes of operation. I'm not sure whether he did this out of generosity or in hopes that he would not have to deal with us again, but either way it was appreciated. Finally, we were up and running with our application.

Or, rather, we are up and running *most* of the time. IBM is feverishly trying to track down an odd little glitch in OS 1.1. Once every few hundred times we try to write a file to disk, the computer tries to write the file into system space and an error results. We must then reboot the system with a consequent loss of data. The error happens so rarely and (apparently) randomly that IBM has been having a hard time tracking it down. Because we write data to disk every few seconds, the amount of information lost in rebooting is not substantial. And the missing data is easily reproduced in our application. If your application is not so fault-tolerant, however, you should make sure this problem has been overcome before buying the CS-9000. The problem has occurred at other installations, so it isn't our hardware that's causing it. In any case, be sure to back up your work on disk frequently.

I have only one continuing source of irritation with the system: the printer. It is awkward to load with paper, frequently jams when operating, and either holds very little paper (if you use the paper holder under the keyboard) or lets the paper drape in front of the operator's feet (if you set a box of paper under the desk and feed the printer from there). I understand that IBM has redesigned the paper bailer to minimize the jamming problem, but the other problems seem endemic to the built-in printer.

Back to BASICs

As I mentioned earlier, I have used the CS-9000 primarily with the BASIC interpreter. The rest of my remarks will center on using this very substantial BASIC. Those readers accustomed to one of the many incarnations of Microsoft BASIC are in for a treat. Unlike most BASICs, you are not limited to 64K bytes of programming space. The interpreter can address as much memory as you have on your system. It also includes the MAT (matrix) functions. Further, it features a broad range of statement modifiers, such as FOR J=1 to 11 (see listing 1, line 80). You can use 8-bit, 16-bit, or 32-bit words. The range of floating-point numbers is approximately 1.0E +/−308 with approximately 15-digit precision. Because the MC68000 uses memory-mapped I/O, all devices (including the printer, screen, IEEE-488 port, etc.) use the OPEN statement (like files), which makes programming I/O routines quite painless.

There are, of course, a couple of usual features of in-

Listing 1: *The program listing for the data-acquisition and analysis routine using the Biomation 8100. Because the bus-management lines of the IEEE-488 are not used by the Biomation, the REN line is used to trigger the laser and the Biomation, and the IFC line is used to trigger the monochrometer stepper-motor (lines 240–250 and line 370, respectively).*

```
1 REM PROGRAM FOR COLLECTING DATA FROM BIOMATION 8100
10 REM INITIALIZE CALL LOCATIONS
20 B=$E000:SREAD=B+$2948:SYSFUNC=B+$2CB8
30 REM DIMENSION ARRAYS.
40 DIM A%(2000),B%(1025),F%(11)
50 LENG=2048
60 REM INITIALIZE IEEE488 ROUTINES
70 DATA 286,10,290,10,0,17,0,12,0,10,0
80 READ F%(J) FOR J=1 TO 11
90 RESTORE
100 REM SET EXPERIMENT PARAMETERS
110 INPUT "BIOMATION SAMPLE INTERVAL SETTING (MICROSEC) ";BIOM
120 INPUT "NUMBER OF SCANS PER MONOCHROMETER SETTING ";REP
130 INPUT "NUMBER OF MONOCHROMETER SETTINGS ";NOSTEP
140 INPUT "DURATION OF PAUSE BEFORE TRANSFER ";ZZZ
150 INPUT "NOISE LEVEL OF SIGNAL ";NOISE
160 INPUT "NAME OF FILE TO SAVE RUN DATA IN ";FILE$
170 OPEN FILE$ AS FILE #1
180 PRINT #1,BIOM
190 PRINT #1,NOSTEP
200 OPEN "#BUSD?" AS FILE #6
210 REM DATA ACQUISITION ROUTINE
220 FOR MON=1 TO NOSTEP
230 FOR SCAN=1 TO REP
240 CALL SYSFUNC(6,F%(6))                !SET REN TO TRIGGER LASER, BIOMATION
250 CALL SYSFUNC(6,F%(8))                !RESET REN
260 WAIT (ZZZ)
270 CALL SYSFUNC (6,F%(1))               !COLLECT DATA
280 CALL SREAD(6.,B%(1),LENG,$0D,$0D,0)
290 FOR I=1 TO 1000                      !UNPACK DATA, ADD COUNT TO MEMORY A%
300 C%=SWAP%(B%(I)) AND 255
310 IF C%>NOISE THEN A%(2*I-1)=A%(2*I-1)+1
320 C%=B%(I) AND 255
330 IF C%>NOISE THEN A%(2*I)=A%(2*I)+1
340 NEXT I
350 NEXT SCAN
360 REM TRIGGER MONOCHROMETER MOVE AND WAIT FOR IT TO STOP
370 T=TIME:CALL SYSFUNC(6,F%(10))        !IFC TRIGGERS MONOCHROMETER
380 FOR I=1 TO 2000:PRINT #1,A%(I):A%(I)=0:NEXT I
390 IF TIME-T<3 THEN 390
400 NEXT MON
410 CLOSE #1
420 CLOSE #6
430 END
```

terpreted BASIC that I miss. Arrays cannot be dynamically dimensioned because the interpreter translates each line of BASIC code into a tokenized pseudocode as it is entered, not as it is executed. This feature makes the BASIC run rather fast for an interpreter. For example, lines 230–340 of listing 1 trigger a laser and the Biomation, collect 2K bytes of data from the Biomation, compare each byte to a noise level, and, if appropriate, add 1 to an element of a 2K data array. Interpreted BASIC does all of this in one second! For that level of speed, I'm willing to live without dynamically-dimensioned arrays. By the way, a compiled FORTRAN version of this program did the same process 12 times in one second.

Another consequence of translating each statement as it is entered is that the BASIC comes with a line editor rather than a full-screen editor. And the editor is a little tricky to use. For example, if you have a variable type error in a program line and edit the line, you may still get a type error prompt. I've found it's best to delete the offending line and retype it correctly.

Line 300 of listing 1 illustrates a couple of interesting points about the BASIC. First, 2 bytes may be stored in

Text continued on page 290

Listing 2: *The program listing for plotting the data from listing 1 on the screen, one monochrometer setting at a time.*

```
1 REM PROGRAM TO PLOT DATA COLLECTED FROM PROGRAM 1
10 CLS
20 INPUT "FILE NAME ";FILE$
30 OPEN FILE$ AS FILE #1
40 INPUT #1,BIOM
50 INPUT #1,NOSTEP
60 DIM DAT(10,2000)
70 FOR I=1 TO NOSTEP
80 FOR J=1 TO 2000
90 INPUT #1,DAT(I,J)
100 NEXT J
110 NEXT I
120 CLOSE #1
130 FOR K=1 TO NOSTEP
140 MAX=-128:MIN=127
150 CLS
160 LOCATE 10,0
```

Listing 2 continued on page 289

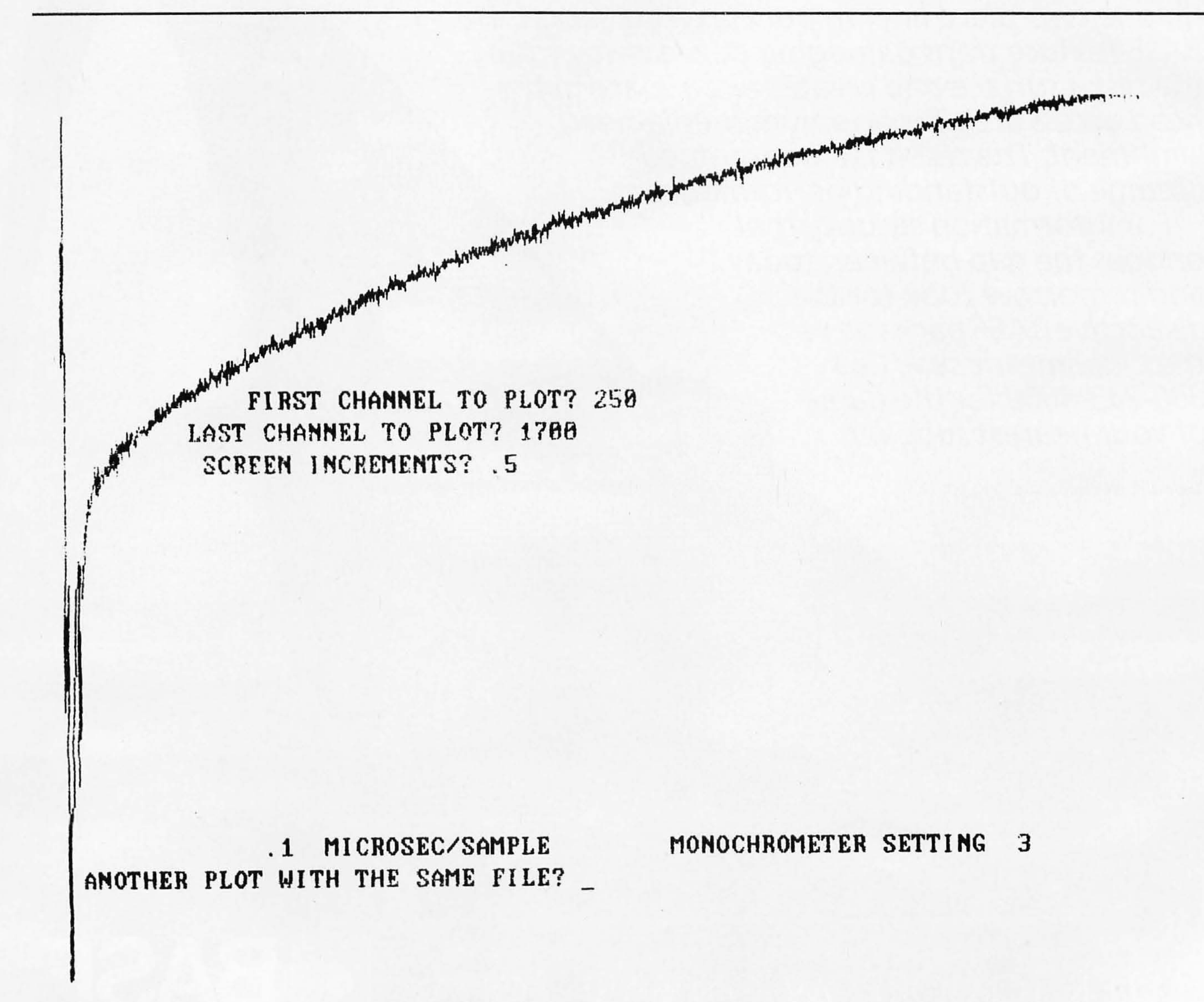


Figure 1: *A screen dump of a plot of a single scan of the Biomation, showing the luminescence decay curve of Benzil excited by a pulsed nitrogen laser. Data was collected from a modified version of listing 1 and plotted using listing 2.*

Listing 2 continued:

```
170 INPUT "FIRST CHANNEL TO PLOT",A
180 INPUT "LAST CHANNEL TO PLOT",B
190 INPUT "SCREEN INCREMENTS",C
200 FOR I=A TO B
210 IF DAT(K,I)<MIN THEN MIN=DAT(K,I)
220 IF DAT(K,I)>MAX THEN MAX=DAT(K,I)
230 NEXT I
240 FACTOR=450/(MAX-MIN)
250 LINE (1,470-((DAT(K,A)-MIN+1)*FACTOR),1,470-((DAT(K,A)-MIN+1)*FACTOR))
260 FOR I=A+1 TO B
270 LINE (-1,-1,(I-A)*C,470-((DAT(K,I)-MIN+1)*FACTOR))
280 NEXT I
290 LOCATE 24,0:PRINT BIOM;" MICROSEC/SAMPLE","MONOCHROMETER SETTING ";K
300 INPUT "ANOTHER PLOT WITH THE SAME FILE",Q$
310 IF Q$="Y" THEN 140
320 NEXT K
330 END
```

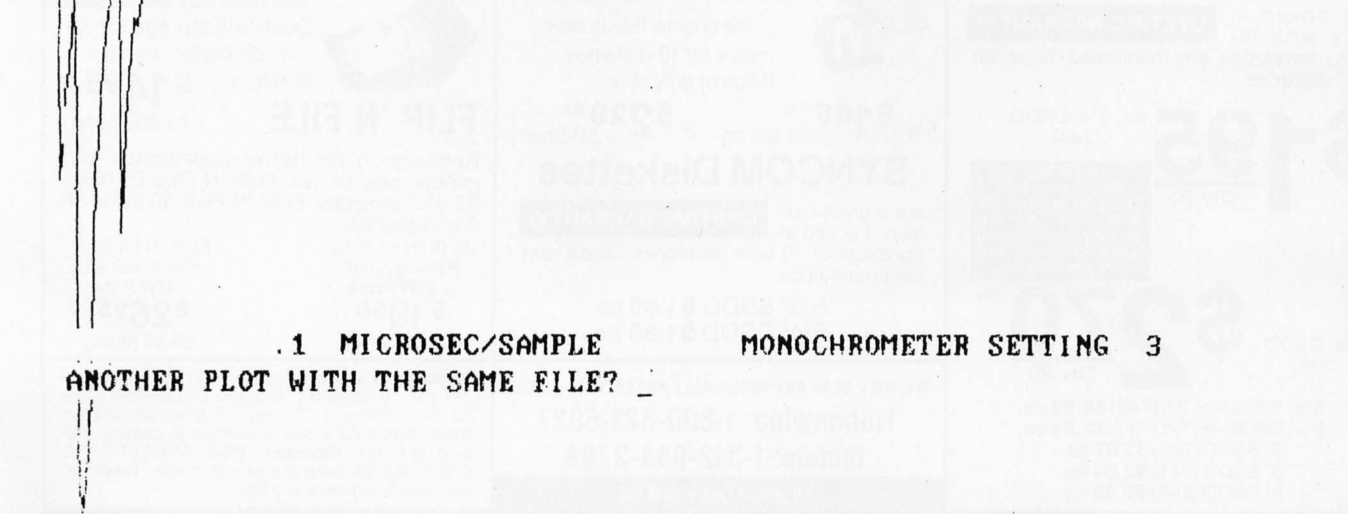


Figure 2: *A screen dump that demonstrates the fine structure of the plot.*

Text continued from page 286:
one 16-bit memory location to save space. The SWAP% function lets you reverse the high and low bytes in a memory location. Of course, performing an AND 255 with the value masks out the high byte. The second point has to do with why line 300 is there at all. It seems that the interpreter cannot perform B%(I) AND 255 and compare it with noise all in one line; apparently, there is a bug in the interpreter. If you do the operations separately, there is no problem. This is the only bug I have encountered in the interpreter.

Lines 80 and 240 in listing 1 illustrate the use of the IEEE-488 port. The operating parameters of the port are entered into a data array and passed to the interface driver by calling SYSFUNC:. Line 70 lists the parameters this program uses. The parameter 286 sets the maximum timeout for a transfer to the succeeding argument (which is 10) times 50 milliseconds; the parameter 290 sets the maximum transfer size without using DMA to whatever follows (10 again); the 0 ends a sequence of instructions, so F%(6) begins a new sequence; the 17 sets the REN line high and the 0 ends that sequence; the 12 resets the REN line, and again 0 ends the sequence; then, 10 sets the IFC line, with the 0 ending the sequence. Thus, the F% array actually contains four different sets of parameters, each invoked by CALL SYSFUNC(dev #, F%(N)), which reads F%(N) to F%(N+I), where F%(N+I)=0.

Let's look at line 20 in listing 1. This line initializes the system calls used in the program. In the new version of BASIC, version 1.1, you do not need to add the call locations.

Listing 1 collects data from the Biomation. Listing 2 displays that data, one monochrometer setting at a time. Lines 250 and 270 of listing 2 do the actual screen plot. Line 250 draws a line from the first data point (scaled for the screen) to itself. That is, it sets the first point of the line. Line 270 draws a line from each subsequent point to the preceding point. The −1, −1 argument says, "Connect this point to the last point." Figures 1 and 2 show screen dumps of sample outputs from listing 2, using data collected from a modified version of listing 2 in which the raw voltages from a single scan of the Biomation were collected.

Summary

The CS-9000 is a very fast and powerful laboratory computer. It has enough I/O ports to please the most jaded palate. The options let you configure the system for most conceivable laboratory applications. The range of numbers it can work with makes it unnecessary to constantly use log values to avoid overflows. The CS-9000 is very affordable. And, above all, the level of customer support sets new standards of excellence for the microcomputer industry.■

Thomas R. Clune (55 Central St., Ashburnham, MA 01430) is physical chemistry laboratory coordinator for the Chemistry Department of Brandeis University in Waltham, Massachusetts.

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by Chuck Weger

Remember when you could tell the difference between a computer and a peripheral? In the old days, computers had front panels full of lights and switches, printers were large, clattering beasts, and modems were big, ugly boxes that connected to special, and expensive, phone circuits. In those times a modem knew its place. But now, here comes a modem with a full-blown Z80 microprocessor in it—the same chip that's in lots of home computers. All of a sudden, the distinction between computers and their peripherals is getting hazy. What do you call a modem that has memory like a computer? In this case, you call it a Rixon R212A Intelligent Modem.

The folks at Rixon have been in the modem business a long time, but they have manufactured primarily industrial products. The R212A and its IBM PC-compatible cousin, the PC-212, are among the company's few ventures into the consumer world. If Rixon keeps producing products like this, the company might have to discontinue some of its industrial business to keep up with the demand of consumer and commercial markets. Not only is the R212A the most sophisticated modem in its class I have seen, it is also easy to use. I'll describe some of the R212A's features in this review.

Setting Up

Photo 1 shows the R212A as it comes packaged with an AC (alternating current) adapter and a modular telephone cable; an instruction manual (not pictured) is also included. It does not come with the RS-232C cable you'll need to connect it to your computer or terminal, but this is a stock item in most computer stores. The modem is packaged in a beige molded case with a black front panel.

The first thing that I noticed about this modem was its front panel, which really wasn't a front panel—or not what I would call one. There is a piece of black anodized aluminum with the Rixon logo, but there are no LEDs (light-emitting diodes), lights, or switches on the panel. In fact, there are no controls or indicators anywhere on the case. And if you're the kind of person who opens the case to see the insides, you'll see that there are no DIP (dual-inline package) switches on the circuit board, either. All the options—and there are plenty in this modem—are set by software commands.

The back panel contains two RJ-11 modular telephone jacks as well as a connector for the power supply. It also contains a standard 25-pin female RS-232C connector labeled DTE (data terminal equipment) for connection to the terminal or computer. Once again, there are no switches or indicators.

Installing the R212A is extremely simple. Run a cable from a serial I/O (input/output) port on your computer or terminal to the DTE connector. The phone line goes in one of the modular jacks with the cable supplied. Finally, plug in the AC adapter. The other modular jack is a real convenience; if you want a telephone connected to the same line, it can be plugged into this jack, saving the cost of a phone-line Y adapter. Note that the whole telephone—not just the handset, as on some other modems—plugs into this jack. Of course, you don't need to plug a phone into this jack. The modem will work fine without one.

To communicate with the R212A, you will need a communications program that allows your computer to send and receive ASCII (American National Standard Code for Information Interchange) characters over its serial I/O



Photo 1: *The Rixon R212A package includes the modem, a modular telephone cable, an AC line adapter, and a manual (not pictured).*

port. This could be a program that makes your computer into a dumb terminal, or it could be a more sophisticated modem program. Both kinds will work with the R212A. Of course, if you are using a terminal instead of a computer, you don't need a program.

As the lack of switches implies, the R212A is controlled entirely from your computer or terminal. Once the modem is connected to the computer, you can type two carriage returns to wake it up. It responds with a sign-on message, shown in the first four lines of photo 2. It also determines automatically the transmission speed of your system, either 300 or 1200 bps (bits per second), and the type of parity, based on the carriage returns you send it. From then on, it accepts ASCII commands. These commands can be entered manually from the keyboard, or you can use a program to send them. In my experience, a fancy modem control program is not needed, since the R212A can do just about everything by itself. The commands are all one or two letters long, so it takes little effort to type them. Table 1 briefly summarizes the R212A's command set.

Features

One of the nicest features of the R212A is its help display. Most user-friendly software packages now have some sort of help facility. It's rare, though, to find a piece of peripheral equipment with one. The R212A's help display, shown in photo 2 as it appears on the screen of my Zenith Z-89 computer, gives a brief description of each command. While the help goes no deeper than this (e.g., you can't ask the R212A to further explain the keyboard dial command), it is sufficient to jog your memory after you've read the instruction manual.

Any intelligent modem should be able to automatically dial a phone number. The R212A can do that easily with the K (keyboard dial) command. Merely type a K, and the modem prompts for the phone number. Entering the number followed by a carriage return causes the R212A to dial the number. The R212A ignores spaces and hyphens, so the number can be entered in the usual manner. Don't try to use parentheses to enclose an area code, though; these have special meanings to the R212A.

In addition to plain old auto-dialing, the R212A has the S (store) command for built-in number storage. The modem can store up to 10 phone numbers; each can be up to 60 characters long. When you want to dial a stored number, you need to enter only its index number (a digit from zero to nine). The numbers are saved in the modem's internal RAM (random-access read/write memory), which has a battery backup in case there's no AC power. Rixon says the battery will last at least two years. In addition to the S command, the R212A has the D (dis-

```
RIXON R212A INTELLIGENT MODEM  REV 4
1200 BPS

H FOR HELP

$ h

K   KEYBOARD DIAL
S#  STORE #
0-9 DIAL #
R   REDIAL
M## MULTI-REDIAL
D   DISPLAY #S
SC  LOGON CHAR
T   TEST
C   CLEAR #S
G   GO ON-LINE
O   OPTIONS
X   HANG UP
A   ANSWER
I   ORIGINATE
NU  HAYES
Q   QUIT
_
```

Photo 2: *The help display generated by the R212A. Note the sign-on message at the top of the screen. The dollar sign is the modem's prompt character. Each of the commands shown is accessed by its one- or two-character mnemonic.*

At a Glance

Name
Rixon R212A Intelligent Modem

Use
Communication over voice-grade telephone lines at 300 or 1200 bits per second (bps)

Manufacturer
Rixon Inc.
2120 Industrial Parkway
Silver Spring, MD 20904
(301) 622-2121

Size
1.5 by 6.25 by 9.7 inches

Weight
2.5 pounds

Features
Direct-connect, 0 to 300 bps plus 1200 bps; accepts ASCII commands from computer or terminal; holds 10 phone numbers plus identifying information in battery backed-up memory

Hardware Needed
Computer or terminal with RS-232C port, along with RS-232C interconnecting cable

Software Needed
Any communications program capable of sending and receiving over the computer's RS-232C port

Documentation
78-page manual in a 5½- by 8½-inch format

Options
None

List Price
$499

Command	Definition
K	Keyboard dial; any telephone number may be entered directly from the computer or terminal keyboard, rather than using a number stored in the modem's memory.
S#	Store a telephone number in location #, where # is a number from zero to nine. The number may be up to 60 characters long, including comments.
0—9	Dial a number stored in the modem's memory (memory locations are numbered zero through nine).
R	Redial the last number dialed.
M	Multiple redial; redials the last number dialed up to 10 times before giving up.
D	Display the phone number directory.
SC	Set the "log-on" control characters; once set, the characters can be used within a log-on sequence to send stored text to the remote system and wait for a response.
T	Test mode. The R212A goes into a local loopback self-test, or a remote self-test if on line.
C	Clear all stored numbers. The R212A prompts to be sure this is really what is wanted.
G	Go back on line if previously disconnected with special "programmed disconnect" character.
O	Option select (see table 3).
X	Hang up the phone line.
A	Forces the modem into "answer" mode when dialing a call (i.e., high-frequency modem tones).
I	Forces the modem into "originate" mode when dialing a call (i.e., low-frequency modem tones).
NU	Select Hayes mode. The R212A will recognize Hayes Smartmodem commands.
Q	Quit; causes the modem to "sign off" and return to noninteractive state. (Calls will still be auto-answered, though.)
PARITY	Typing the word PARITY in uppercase causes the R212A to detect the parity your system is using.

Table 1: *R212A command summary.*

play) command for displaying the directory. A sample directory is shown in photo 3.

You'll notice in this picture that the phone numbers have text associated with them. This is a handy feature; I use it to save the name and/or description of the system associated with each phone number. You have to use a slash (/) following the phone number to indicate text. Everything after the slash is interpreted by the R212A as text.

Also shown in photo 3 is an example of the S command. At the bottom of the screen I typed S7, which means store a number in slot 7. The modem responded with the existing contents of slot 7, and with a message questioning whether I really wanted to change what was in that slot. I did, so the modem then prompted me for the new phone number—a simple, logical procedure.

The R212A is well matched to modern telephone systems. For example, it can detect the presence or absence of dial tones, and it will inform you if it can't get a dial

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Who Changed and Rearranged The Facts?

Again, ShuffleBuffer's the culprit. You want to move paragraph #1 down where #3 is? Want to add a chart or picture? No problem. No mystery, either. Any buffer can give you FIFO, basic first-in, first-out printing. And some buffers offer By-Pass; the ability to interrupt long jobs for short ones. But only ShuffleBuffer has what we call Random Access Printing — the brains to move stored information around on its way to the printer. Something only a computer could do before. Comes in especially handy if you do lots of printing. Or lengthy manuscripts. Or voluminous green and white spread sheets. And by the way, ShuffleBuffer does store up to 128K of information and gives you a By-Pass mode, too.

And Who Spilled The Beans 239 Times?

Most buffers can't tell the printer to duplicate. If they can, they only offer a start/stop switch, which means you're the one who has to count to 239. Turn your back on your buffer, and your printer might shoot out a room full of copies. ShuffleBuffer, however, *does* control quantity. Tell it the amount, and it counts the copies. By itself.

So, What's The Catch?

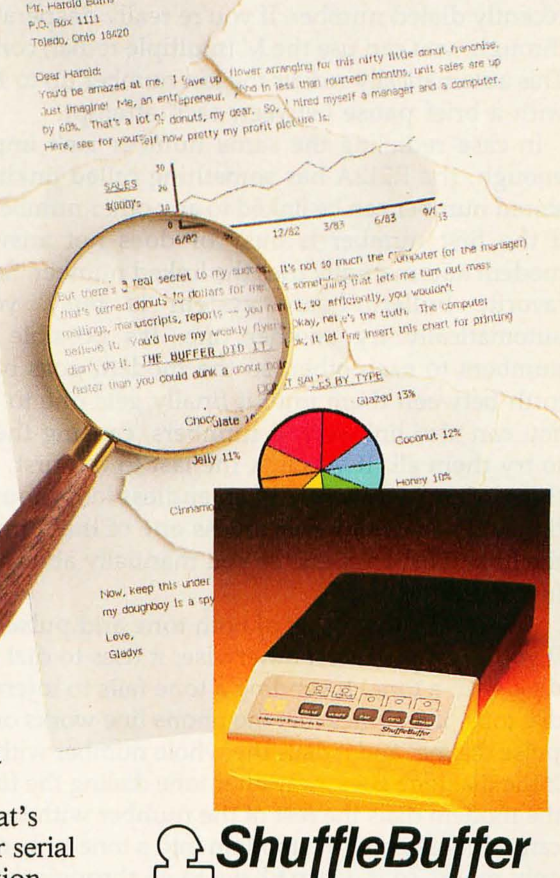
There isn't any. Sleuth around. You won't find another buffer that's as slick a character as this one. You also won't find one that's friendly with any parallel or serial computer/printer combination. This is the world's only universal buffer.

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* Based on an average 4000 character letter & 128K buffer.



ShuffleBuffer
The Buffer with a Brain

Interactive Structures Inc.
146 Montgomery Avenue
Bala Cynwyd, PA 19004

```
$

$ d
#0  555 1212-Directory Assistance
#1  (301) 555 1212-Maryland Directory Assistance
#2  (202) 224 3121-U.S. Congress
#3
#4
#5
#6  (202) 555 1212-Sample logon [This is the logon sequence.]
#7  555 1213
#8
#9

BATCH
This is some batch stuff
$

$ s7
OLD:  555 1213
VERIFY OR STORE  (V/S) S
NEW: 555 1212

$ _
```

Photo 3: *The R212A's directory display. The notations next to the phone numbers are stored as ASCII text by the modem. "BATCH" is a way to run a set of commands. The bottom of this display contains an example of storing a new phone number.*

Command	Definition
&	Wait for intermediate dial tone; generally used with PBX (private branch exchange) systems where an access number must be used to get an outside line.
%	Pause 5 seconds; can be used to wait for access tone on long-distance services such as Sprint and MCI.
P	Forces pulse-dial mode for subsequent digits.
T	Forces tone-dial mode for subsequent digits.
L	Link to another stored number if this number is busy.
/	Comments. Everything following a slash character is treated as a comment. Comment characters are displayed in the directory but not dialed.
Space	Ignored. A space can be used within telephone numbers to improve readability.

Table 2: *Special characters in telephone numbers.*

tone by telling you "dead line." It can also interpret most busy signals and will inform you if the line is busy or if there is no answer. If you wish, you can use the R (redial) command to automatically redial the most recently dialed number. If you're really desperate to get through, you can use the M (multiple redial) command. This automatically redials the last number up to 10 times, with a brief pause between each attempt.

In case redialing the same number isn't impressive enough, the R212A has something called linking. Any stored number can be linked to any other number. Then, if the first number is busy or does not answer, the modem automatically tries the linked number. So if your favorite bulletin-board system is busy, you can automatically try another one. It's possible to link numbers to each other, so the modem goes back and forth between them until it finally gets one to answer. You can also link several numbers, causing the R212A to try them all. If you link the last to the first, you get the modem's equivalent of an endless loop. Your phone line will be busy forever unless one of the numbers on the linked list answers or you manually abort the dialing operation.

The R212A is capable of both tone and pulse dialing. If you don't instruct it otherwise, it tries to dial the first digit with a tone. If sending a tone fails to interrupt the dial tone, it assumes that the phone line works only with pulse dialing, and it dials the whole number with pulses. If the dial tone goes away after tone dialing the first digit, the modem dials the rest of the number with tones. You can, of course, put the modem into a tone-only or pulse-only mode, so it doesn't have to go through this detective work each time it dials. Finally, the letters T and P can be embedded in phone numbers to manually switch between tone and pulse dialing. This is useful if you're on a PBX (private branch exchange) that understands only pulses, but you dial an access code to get an outside line, which can use tones. The R212A can handle the whole dialing operation, including waiting for secondary dial tones. You can also use the percent (%) character to cause a 5-second pause anywhere in a dialing sequence. Table 2 summarizes the special characters allowed within telephone numbers.

Advanced Features

In addition to storing phone numbers, text, and link codes, the R212A can store log-on sequences. A log-on sequence is a series of ASCII characters that the R212A sends down the phone line once it has detected a modem on the other end. This can be an account number, a password, or whatever. In effect, the log-on sequence lets you automatically log on to a remote system without lifting a finger. The log-on sequence is stored by enclosing it in square brackets ([ ]) when you store the phone number.

The log-on sequence feature is very versatile. It can, for example, contain any ASCII control characters, not just printable ones. It can contain a special character that causes the R212A to wait for a specific response from the remote system before proceeding with the rest of the sequence. It can also contain secure characters, which are never displayed in the R212A's phone number directory. Secure characters are enclosed in parentheses when you first store the log-on sequence. This is a useful feature if you set up your modem to be used by others who should not know things like remote system passwords.

Another advanced feature is the batch facility. Sequences of commands can be enclosed in angle brackets (< >). The R212A buffers everything received after an open bracket and executes it (without echoing or prompting) after it sees the closed bracket. Therefore you can write a program that sends a series of commands to the modem all in one batch, without cluttering up your screen display. The contents of the batch buffer

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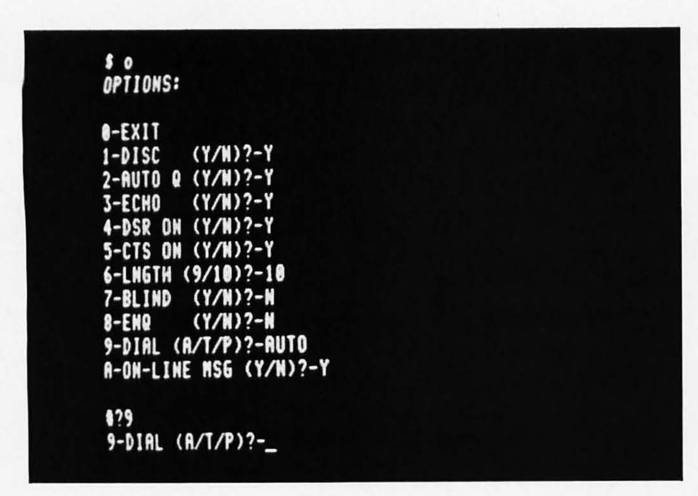


Photo 4: *The options menu displayed by the R212A in response to the O command. Option 9 (dialing mode) has been selected.*

always appear on the directory display (photo 3), so you can see what your computer has been sending.

In case you aren't satisfied with the way the R212A works, the designers give you a chance to change it with the O (options) command. This command calls up the menu shown in photo 4. There are 10 user-selectable options shown in the menu. Some of these deal with such details as how the modem controls certain RS-232C lines, while some deal with more mundane issues, such as whether the modem sends the message ONLINE to you when it detects a carrier. Table 3 gives a brief summary of the options. Most people, however, should find that the default options are sufficient; I didn't even look at the other options until I had thoroughly played with the auto-dialing and other features.

If your telephone system is old and uses dial tones with unusual sounds, which the modem might not be able to detect, you'll find that you need the O command and option number 7. Option 7, BLIND, causes the R212A to begin dialing a number after five seconds have elapsed, even if it doesn't detect a dial tone.

Number	Name	Definition
1	DISC	Stores a special disconnect character. The character selected with this option, if typed 3 times in quick succession, will cause the modem to return to keyboard mode without disconnecting the telephone line.
2	AUTO Q	Determines whether or not modem automatically exits keyboard mode 2 minutes after last keyboard entry.
3	ECHO	Determines whether or not modem echoes back characters when in keyboard mode.
4	DSR ON	Causes the Data Set Ready (DSR) lead to be either permanently on or on only in data mode.
5	CTS ON	Causes the Clear To Send (CTS) lead to be either permanently on or on only when the modem is ready to transmit.
6	LNGTH	Selects 9- or 10-bit character length in 1200 bps mode.
7	BLIND	Determines whether modem tries to detect dial tone automatically or merely dials blind after a 5-second wait.
8	ENQ	Determines whether modem sends the ASCII character ENQ to a remote modem for handshaking purposes.
9	DIAL	Selects tone, pulse, or automatic dialing.
A	ONLINE MSG	Determines whether or not the modem issues an ONLINE message when it detects a remote modem's carrier.

Table 3: *R212A options (set by the O command).*

Finally, in keeping with its industrial origins, Rixon has a version of this modem available without the case, for use in a card cage. If you have many modems at one site, this would be a good way to keep your modems organized.

Other Nice Touches

The R212A has some other nice features, too. For example, the C (clear) command clears out all the stored phone numbers. Fortunately, the R212A gives you an "are you sure?" prompt before doing this. There is also a built-in self-test mode that loops back (connects the modem to itself) to make sure signals are being transmitted and received correctly.

The R212A can also emulate a Hayes Smartmodem. This means that the Rixon modem can operate like a Hayes Smartmodem so that people who have invested in software that understands the Hayes modem can use the R212A with their old software. The Hayes modem is much more limited than the Rixon modem, however; it doesn't have number storage, linking, or log-on sequences, and it doesn't detect dial tones. Also, it doesn't provide a help menu. I like all the Rixon features, so I haven't really used the Hayes-emulation mode except to test it.

Documentation

The R212A comes with a very comprehensive 87-page manual. The manual is well designed, full of figures and examples, but was obviously written with the industrial market in mind. It's a bit dry, and the organization is occasionally puzzling. For example, on page 4, it tells you how to disassemble the modem. I think I would rather see some setup information first. An index would also be useful. There is, however, a nice foldout summary of all Rixon and Hayes commands and options.

Complaints

The lack of external adjustments makes the modem extremely simple to use; it cannot accidentally be set for the wrong speed, parity, or operating mode. The absence of controls also means that the modem can be located anywhere that's convenient; it doesn't have to be within easy reach of the operator. The absence of indicator lights or LEDs is another matter. Some people find it comfort-

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ing to watch the "transmit data" light on a modem wink at you as the bits are swallowed by the telephone network. You don't get that with the R212A. People who are accustomed to the Hayes Smartmodem may notice that the Rixon lacks the Hayes's monitor speaker. Personally, I don't care to eavesdrop on modem conversations, so I don't mind the lack of a speaker.

These features aren't missed if everything is working, but if you're trying to track down a problem, like a broken wire in your RS-232C cable, you begin to see the need for them. For example, my one-year-old daughter got her hands onto the computer keyboard when I was experimenting with the modem. I returned to find that the modem would not respond to the computer; nothing I could type or do would make it respond. Finally, I discovered that she had somehow entered the command to put it into Hayes mode, so none of the Rixon commands I was trying had any effect. I suppose this is an argument in favor of child-proof computers.

Since the R212A is a new product, Rixon is bound to have its share of shakedown problems with it. I have experienced two such problems. One was an undocumented "feature," while the other was actually a hardware failure.

The feature problem arose because Rixon designed this modem to be compatible with a wide variety of terminals and computers. Some of these terminals apparently don't understand that normal modem handshaking requires one RS-232C signal (called DTR, or data terminal ready) to be active when talking to the modem. To get around this, Rixon installed a pull-up resistor on this line so that DTR is always active. That's fine most of the time, but it means that, unless the modem is turned off, it answers the phone—even when the computer is turned off. Not a very useful situation. The people at Rixon were very helpful when I complained about this and they told me how to disable it. The solution required cutting that pull-up resistor on the DTR line (R79 on the circuit board). This is no big deal, but people with no hardware experience might feel better asking a friend to do it. It's easier just to unplug the modem when it's not in use.

The second problem was a fluke. During a thunderstorm, the phone line apparently took a lightning-induced jolt. It was not enough to knock out the phones, but it did cause the modem to behave peculiarly. For example, the modem kept the phone line off the hook when it was not supposed to. It turned out the lightning had zapped a protective device. (Better than zapping the whole modem, I thought.) Since my modem was only a few weeks old at the time, the people at Rixon replaced it with a new one, no questions asked. We have had more storms, but the replacement modem has not had any problems.

Conclusions

The Rixon R212A is an extremely intelligent modem that has auto-dialing features more powerful than many modem programs. It supports stored numbers, identification text, log-on sequences, and several forms of autoredial. It communicates with the user through a series of ASCII character commands that are documented in a self-contained help facility. The R212A is extremely easy to set up and use, yet offers many powerful options for sophisticated users.

Some people may find the total lack of switches and indicators difficult to accept; in normal operation, however, they are not missed.

Anyone who is in the market for a 300/1200 bps modem would do well to consider the R212A. At $499, it is definitely an "intelligent" choice.■

Chuck Weger (c/o Oldenberg, 331 6th St. NE, Washington, DC 20003) is an independent consultant specializing in computer graphics. He was formerly on the technical staff of Computer Sciences Corporation.

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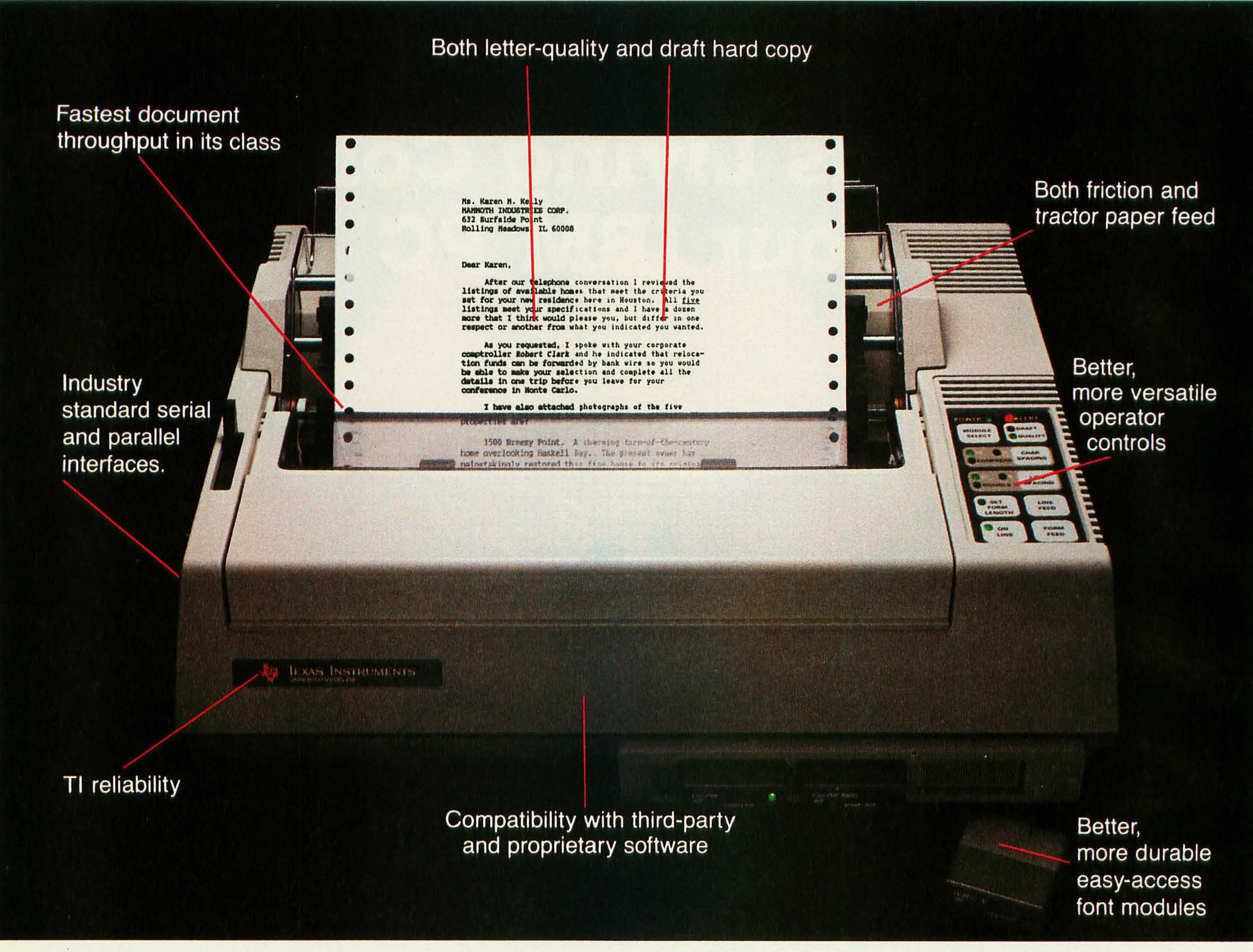
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by Peter V. Callamaras

Imagine finding one package that combines the elements of hardware, software, and firmware with some general-purpose business applications and doesn't require a master's degree in computer science to understand or to use. In addition, the package understands plain ordinary English. What would you call it? Incredible? A lifesaver? Well, Excalibur Technologies Corporation calls it Savvy.

Savvy is a system that runs on an Apple or an IBM PC (Personal Computer) and is unique in the personal computer arena. The Apple hardware consists of a plug-in card for slot 7 of the motherboard. Much like the CP/M cards available for the Apple, the Savvy card contains a Z80 processor and support chips plus the necessary Savvy ROM chips. The Apple's 6502 processor becomes a subordinate controller for the microprocessor. The IBM PC, on the other hand, requires no unique hardware additions. The Savvy software consists of four disks containing a set of business-type applications, a set of demonstration programs, and a robot programmer.

Ease of Use

The intent of Savvy is to make it easy for the noncomputer-oriented Apple or IBM PC owner to perform business and professional tasks. Actually, easy is an understatement. Savvy usually knows what you want to do, even if you misspell the command. The operating system is oriented toward human or natural language.

Usually, if you want to perform a particular set of operations, you must follow a very precise, unforgiving set of instructions. For instance, if you want to scan a database for any BYTE articles on AI (artificial intelligence), you would follow this scenario:

1. Call the search-retrieve module.
2. Input the correct information in the key *search fields.*
   Example: first search field = BYTE
   second search field = Article
   third search field = Artificial Intelligence
3. Initiate the database manager that retrieves the records matching your search criteria.

To perform the same operation with Savvy, all you need to enter is: "get me all the BYTE atricles on artificial intelligence." The system then retrieves the articles. Note the misspelling of the word articles. Normally, if a misspelling occurs, you get an error message and must reenter the data. This system can usually figure out what you mean. The process Savvy uses is called adaptive pattern recognition, or learning.

The learning comes from you. The more you use the system, the more it learns. The Savvy system builds up patterns to compare with your input. If it finds one or more exact match, Savvy returns those items. If there is no match, however, Savvy makes a guess by finding a pattern that comes close to your input. For example, if you ask people to identify a city from a skyline picture, they mentally match the picture to skylines they have seen before. Most people can easily tell the difference between New York and Paris, for instance. If you show them pictures of 10 different skylines, they should be able to identify them easily. This is what Savvy does.

At a Glance

Name
Savvy

Manufacturer
Excalibur Technologies Corp.
800 Rio Grande Blvd. NW
21 Mercado Plaza
Albuquerque, NM 87104
(505) 242-3333

Hardware
Z80-based plug-in card on Apple; four applications disks

Computer
Apple (II, II+, IIe), 48K- or 64K-byte IBM PC; two 5¼-inch floppy-disk drives; optional 80-column display, monitor, and printer

Features
Integrated operating system, pattern recognition, virtual memory, natural-language programming, 63-place decimal arithmetic

Compatibility
IBM PC, IBM PC XT, other PC-compatibles

Documentation
146-page programming manual and 330-page loose-leaf reference manual

Warranty
Limited one-year

Price
$950

Audience
Nontechnical computer users; business and professional computer users desiring an easy-to-use set of programs; those interested in a pattern-recognition system

It gives you the best answer based on patterns it has observed previously.

To continue the skyline analogy, if you ask people to identify a city and then show them an evening picture of the skyline from a slightly different angle, they can probably connect the two. Savvy does this also; in fact, the more you use the system, the better it discriminates between patterns. Excalibur Technologies claims to have a proprietary method of ensuring the integrity of Savvy's pattern-recognition system so you can't overload it with too many patterns.

There is no need for the user of Savvy to have any particular computer skills or background. The system does everything possible to make it easy for the noncomputer-oriented user. For example, if you want to temporarily lock the value of an item or a variable, you tell Savvy to "freeze" the item. When you want to change the value, you simply "thaw" the item. The developers of Savvy have gone out of their way to eliminate as much computer jargon as possible.

This leads us to a strong point in the Savvy system: the ability to program without any programming background. You use your own words to describe what Savvy is supposed to do. It is very close to programming in your natural language. As an example, instead of coming up with some algorithm to add two numbers, multiply the sum by a third number, and print the result, you simply tell Savvy to "take number one, add it to number two, then multiply the sum by a third number and display the result," using almost those exact words.

The robot programmer that comes with the Savvy system, one of the more highly touted parts of the system, is designed to help you establish your own databases. You can use it *only* to write databases. For instance, if you want to create a database for birthdays, you can use the robot programmer to write it. You follow the manual and prompts to configure the input formats, relations, search criteria, and output. Then the robot programmer writes the code while you watch.

When the robot finishes, you can input the names, dates, addresses, and whatever else you want in your database. Once it is established, you can search for, update, and output information from it. Typically, you might ask it to list all family members who have birthdays in March or all the members of the local church who were born on the 15th of any month. The relationships can be as simple or as complex as you wish, and you ask for the information in plain English.

Applications

The Savvy applications programs include a text processor with a mailing-list feature and a set of standard business accounting applications, with accounts receivable, accounts payable, inventory management, payroll, and general ledger.

The text processor is not designed for heavy word-processing applications but works fine for writing short letters. The mailing-list feature enables Savvy to generate your printed letters. File size is not the problem here; the software just isn't available yet.

In the payroll module, you set up a payroll file, subtract any individual deductions and taxes, record time data, and print out both checks and a payroll summary report.

The accounts-payable/receivable packages track receipts and expenditures by client or supplier as well as service charges, past-due accounts, payment due dates, and all the other standard AP/AR data.

The general ledger tracks your accounts, prints checks for expenditures, runs trial balances and prints income statements.

Finally, the inventory-management program establishes your inventory and tracks changes in stock levels. You can set up the inventory to include parts numbers, descriptions, stock levels, costs and prices, reorder points, and storage-location information.

As you can see, Savvy is primarily designed for small business or professional use, and in that context it does an adequate job. If you find that the applications don't meet your needs as written, you can enhance or modify them as you wish. The package includes the source code, and you can use the programming facilities of the Savvy system to make any changes.

Documentation

The accompanying documentation is an important part of the Savvy system. I received a large loose-leaf

binder and a separate Savvy programming manual. The manual is fairly straightforward, and you are led through the various Savvy functions with extensive use of the tutorial approach and actual screen images of the dialog between the user and Savvy. Almost no technical jargon is included. My only complaint is that Excalibur Technologies used a rather small typeface and packed every page full of information. Consequently, it takes a long time to go through the documentation.

Conclusion

Savvy is a combination of hardware, software, firmware, and applications programs designed for small business or professional use. The actual system consists of a plug-in board (for Apple users) and four disks. The package also includes two sets of support documentation.

Communicating with the Savvy system through English-like conversations makes it very quick and easy for the noncomputer-oriented user to get up to speed. The more you use the Savvy system, the more it recognizes your commands. You can use the system's robot-programming capabilities to write all sorts of databases using English-like instructions. Savvy requires no specific programming skills and after using it for a while, you can become quite adept at writing your own Savvy programs.

The applications are pretty much no-frills business programs, consisting of a document- or letter-writing module with mailing-label capabilities, payroll, accounts-payable/receivable modules, general ledger and inventory management. You can modify or enhance any of these modules.

The documentation is voluminous, but complete, and does a good job of leading the user through the various functions and capabilities of the Savvy system.

Savvy costs $950; a fairly large investment. You also need at least a 48K-byte Apple system (Apple II, II Plus, or IIe) or a 64K-byte (currently it won't use more) IBM PC, two disk drives, a monitor with an 80-column display, and finally a printer. To make a choice, you must balance the unique operating and programming capabilities Savvy offers against a set of specific application programs for your word processing and business needs.

Overall, Savvy is a very easy-to-use, friendly system that requires almost no background in computers. I enjoyed using the Savvy system, but reviewing it was not easy, as I could have spent many pages on any one of its capabilities. I look forward to seeing how Savvy's unique abilities affect the way people interact with computers in the future.■

Peter V. Callamaras (HQ AFCC/EPPB, Scott AFB, IL 62225) is an officer in the Air Force. He has degrees in computer technology and biological sciences, and a master's degree in systems management. He has been interested in computers since 1966 and was formerly the service department manager of a computer store.

Circle 310 on inquiry card. →

The Micro-Sci Gameport III for the Apple III

How to upgrade your Apple III to an Apple II and recapture the fun of computing

by William J. Purpura and Paula K. Purpura

The Apple III is a high-powered, sophisticated computer, but you can't use it to play Space Raiders, Choplifter, or any Apple II games that require a joystick or paddles.

The Apple III was designed to utilize more than 64K bytes of RAM, and this design did away with the permanent memory locations used by the Apple II paddles. The new joystick input designed for the Apple III, although it has a much better A/D (analog to digital) converter than the Apple II's, is not much help. Most Apple II games were written to use the Apple II paddles or joysticks, and we couldn't find any game software designed specifically for the Apple III. Until now, Apple III owners have had to sit back and let the fun slip by.

Now, Micro-Sci (2150 South Hathaway St., Santa Ana, CA 92705, (714) 662-2801) has come to the rescue with the Gameport III. Gameport III is an inexpensive ($74.95) card that plugs into an Apple III slot to emulate the Apple II's normal game I/O (input/output) port. With this slick little board in place, most Apple II game software will run on the Apple III.

Photo 1: *The Gameport III board.*

Micro-Sci has assured us that it has found only one Apple II game, Frogger, that does not work with the Gameport III. Frogger uses a unique joystick reading routine, which is sensitive to the individual joystick used and causes problems on both the Apple II and the Apple III.

Installation of the Gameport III is extremely easy (just insert it in a slot), and the instructions provided by Micro-Sci are simple. One caution: the 16-pin connector from the joystick or paddle must be aligned properly in the socket on Gameport III's board. If, for example, the game won't recognize the joystick button or the position of the joystick, the cable is probably not plugged in correctly, so double-check the installation before powering up your computer.

Once the hardware is installed, the Apple II emulation disk supplied with the Apple III must be modified to handle the Gameport III. Micro-Sci provides a disk that will simplify this chore. You boot Micro-Sci's disk, which will then ask for the Apple II emulation disk and will modify it without further action on your part. The whole process takes a few minutes.

A few older versions of this board may require a minor hardware modification to run correctly. This is due to a problem discovered after the first units had been in the field awhile. When the Gameport III is activated in something other than Apple II emulation mode, it causes problems with the normal Apple III SOS (super oper-

ating system) operation. For this reason, the Gameport III is disabled automatically on power-up or CONTROL-RESET.

To make the Gameport III operational, the user must press button one on the joystick or paddles. (Remember to do this while the game is loading, or you might end up with certain incorrectly initialized inputs.)

It seems that a significant amount of EMI (electromagnetic interference) noise is generated inside the Apple III card-slot area. This high level of noise, particularly during disk operation, occasionally caused the Gameport III to turn on, leading to all sorts of system failures. This happened to us during a disk-copy operation, which failed with a "Stack Overflow" message.

The solution to the problem turned out to be simple.

In Apple II emulation mode, the Apple III can only output the high-resolution color signal on the NTSC pin.

A 0.1 micro-farad capacitor (ceramic type, nonpolarized) must be soldered between pins 2 and 8 of the 16-pin game connector on the trace side of the old version of the Gameport board. Micro-Sci assures us that all new boards have this modification, and anyone who has experienced such system failures with their board should contact the Micro-Sci Customer Service Group at (714) 662-2801.

Anyone who is using an RGB (red, green, blue) monitor with the Apple III should be aware that in Apple II emulation mode, the Apple III can only output the high-resolution color signal on the NTSC (National Television System Committee) pin. This means that such monitors can only display color games in black and white. The problem is in the design of the Apple III and is not a fault of Gameport III. The exception is the Electrohome RGB monitor, since Electrohome has an adapter board to convert the NTSC signal back to RGB. Unfortunately, this board will work only with Electrohome monitors.

An annoying aspect of using the Gameport III is that each time the user wants to run a new game or use the computer in normal Apple II emulation mode, the system must be rebooted. One of the game manufacturers' piracy-prevention strategies is to set up disks so that the user cannot exit to the operating system while running a game. The rebooting procedure can be frustrating (particularly when you're reviewing lots of games), but it does not detract much from the joy of turning the serious and dull Apple III into a fun-loving Apple II.

Name	Manufacturer
A2FS.1	Sublogic
ABM	Muse
Alien Rain	Broderbund
Alien Typhoon	Broderbund
Bug Attack	Cavalier
Cannon Ball Blitz	Sierra On-Line
Castle Wolfenstein	Muse
Choplifter	Broderbund
David's Midnight Magic	Broderbund
Dog Fight	Microlabs
Falcons	Picadilly
Fire Organ	Vagabond
Jaw Breaker	Sierra On-Line
Lunar Leeper	Sierra On-Line
Olympic Decathlon	Microsoft
Pest Patrol	Sierra On-Line
Planetoids	Adventure International
Pool 1.5	IDSI
Raiders of the Lost Ring	Cavalier
Raster Blaster	Budgeco
Snack Attack	Data Most
Sneakers	Sirius
Space Invaders	Apple
Space Raiders	United Software of America
Space War	Apple
Star Blazer	Broderbund
Star Cruiser	Sirius
Suicide	Picadilly
Super Invader	California Pacific
Thunderbirds-GX	Urban Soft
Zenith	Gebelli

The above list is by no means comprehensive.

Table 1: *The following are games we tested with the Gameport III that require either paddles or joysticks.*

Summary

The Gameport III is a must for anyone with an Apple III who would like to run Apple II game software. The price is not out of line for the fun provided. Check to be sure that the unit you buy already has the capacitor modification for reliability.■

At a Glance

Name
Gameport III

Use
Permits the use of Apple II paddle/joystick game software on the Apple III

Manufacturer
Micro-Sci Corporation
2150 South Hathaway St.
Santa Ana, CA 92705
(714) 662-2801

Price
$74.95

Components
Card, disk

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The Videx Ultraterm

A video-display card that enables the Apple to display up to 160 columns or 48 lines

by Peter V. Callamaras

The Videx Ultraterm is a new video-display card designed to plug into any Apple II (II, II Plus, or IIe) to enable the Apple to display more than its standard 40 columns.

Before the introduction of this display card, Apple owners had only two choices concerning the number of columns they could display: they could accept the standard 40 columns or add a peripheral card to give the Apple 80 columns. In either case the number of rows, or lines displayed, was limited to 24. The Ultraterm offers Apple owners a greater choice of displays (see table 1).

In addition to adding to the amount of information you can display on the screen (see photo 1), the Ultraterm actually enhances the visual display with these features:

- a standard high-resolution character set (7- by 9-dot font)
- a high-quality character set (9- by 16-dot font)
- the ability to choose between normal or inverse-video display
- the ability to display the characters in either a highlight, normal, or lowlight mode (this refers to the relative brightness of the characters on the screen)
- a 15-character line-drawing set as part of the standard character set
- seven block graphics characters as part of the standard character set
- 96 ASCII (American National Standard Code for Information Interchange) characters with true descenders

The Ultraterm also gives you the ability to "program" your video display using any or all of the available modes (highlight, lowlight, inverse, etc.), a built-in soft switch that will automatically give you the 80-column mode when you boot either Pascal or CP/M, and a well-written users manual.

The features are impressive, yet the Ultraterm is also easy to install and use. After you open the top of the Apple and ground yourself to the power supply (by touching the large gold unit in the left-rear corner of the computer), simply plug the Ultraterm board into one of the Apple's expansion slots and plug a two-wire molex

Photo 1: *An example of one of the text formats possible with the Videx Ultraterm card for the Apple II. In this mode, the Apple can display an incredible 48 lines of 80-column text.*

At A Glance

Name
Ultraterm Video-Display Card

Manufacturer
Videx Inc.
897 NW Grant Ave.
Corvallis, OR 97330
(503) 758-0521

Price
$379

Software
Demonstration disk

Hardware Required
Apple II, II Plus, or IIe

Capabilities
40–160 columns, 24–48 lines, two character sets, four intensity levels, added graphics and line-drawing character sets

Documentation
Well-written 78-page manual

Warranty
90 days, workmanship and material

Audience
Any Apple owner desiring more than 40-column display; all business or professional Apple users

The Preboots

Name
Ultraterm Applewriter II/IIe Preboot

Price
$29

Audience
Apple users who want Applewriter II in more than 40 columns and 24 lines

Name
Ultraterm Visicalc Preboot

Price
$69

Audience
Anyone who uses Visicalc

connector into the Ultraterm board (one end of the connector into the normal Apple video-output port and the other to your monitor). Put the top back on your Apple, turn it on, and begin.

With the Ultraterm, you must use a monitor for a video-display terminal because a standard television set cannot handle an 80-column display. The monitor *must* have at least a 15-MHz bandwidth to handle up to the 132-column mode or a 20-MHz bandwidth for the 160-column mode (extended bandwidth is required because of the Ultraterm's 28-MHz clock). It must also have a high-persistence phosphor because the Ultraterm uses an interlaced display mode to give more than 24 lines in the 32-/48-line modes. Potential Ultraterm owners should examine their current monitors or any potential monitor purchase to insure that they meet these criteria.

Columns	Rows	Display type
40	24	Normal Apple display
80	24	Standard 80-column display
80	24	High-quality 80-column
80	32	Extended 80-column
80	48	Extended 80-column
96	24	Extended-column display
128	32	Extended/Visicalc display
132	24	Super-extended display
160	24	Ultra-extended display

Table 1: *The Videx Ultraterm offers Apple owners a choice of displays.*

Tests conducted by Videx have shown that the following monitors can be used successfully with the Ultraterm:

- The Apple Monitor III is suitable for all displays except 160-column. It is the Videx monitor of choice for use with the Ultraterm.
- A NEC JB-902M will display all video modes, including 160-column, but the short-persistence phosphor causes the display to flicker. The 9-inch screen makes anything over 80 columns hard to read.
- The NEC JB-1201M will perform the same as the NEC JB-902M, but the 12-inch screen makes it easier to see 80+ columns.
- The Ledex/Amdek 100 was the monitor I first used with the Ultraterm. It worked well in 80 columns, but is unsuitable if you wish to take advantage of the extended-column modes.
- Amdek 300A is the monitor I now use. It is superb; not only does it have an amber screen (easier on the eyes), but it can take advantage of all the Ultraterm features. It has both the necessary bandwidth and phosphor persistence needed to go to 160 columns and 48 rows.

If you are not now using or contemplating buying one of these monitors, I would encourage you to check with your local computer dealer about the compatibility of other specific monitors. If your dealer is unable to help you, check with the Videx technical services *department.* The folks at Videx are happy to answer consumer questions.

The only problem I had while using the Ultraterm was with some of the popular Pascal programs that normally display in the Apple 40-column mode. Specifically, PFS, Wizardry, and Visischedule will "fool" the *Ultra*term into thinking it is supposed to be in the 80-column mode, and you end up with no display! The solution is to plug your monitor directly into the Apple's video-output port. Or, if you use any of these software packages often, you can install a Videx switch plate for a simpler switchover.

Besides the obvious advantages of the expanded-display area, there are some other handy features available with the Ultraterm. Using the programmable "alternative attributes," you can display either standard or high-quality character sets in inverse or normal video with highlight or lowlight brightness. You can also get other character sets from Videx on EPROMs (erasable programmable read-only memories) featuring some common foreign characters.

Special Features

The high-quality character set uses a 9- by 16-dot matrix instead of the standard 7- by 9-dot matrix. It is easier to read, although I found the standard set satisfactory. The relative brightness of the display can be controlled with the highlight/lowlight feature. This means that you can have a screen display with some characters brighter (or dimmer) than others. (This can be useful for emphasis.) You can also combine the highlight/lowlight feature with the normal/inverse screen capability to extend the emphasis capabilities of the screen display. For instance, you could show an important caution or warning message in an inverse highlight, while the normal text would be in a lowlight, normal-video mode. The uses are limited only by your imagination.

Again, both Pascal and CP/M will come up automatically in 80-column mode; there is no need to buy additional hardware or make any modifications. I found this feature handy because I often switch back and forth between programs. With the standard Videx Videoterm I sometimes forgot to throw the switch to the right output. The built-in soft switch makes the Ultraterm easier to use.

The Ultraterm's capabilities are also programmable, so you can customize your screen displays if you wish. A chapter in the manual addresses the various methods and techniques for programming your screen displays to take advantage of the Ultraterm's wide capabilities. BASIC, Pascal, and assembly-language information is included. One note: there are changes in how some video displays work with the Ultraterm installed, such as the loss of the FLASH command capability, but this is all documented in the manual.

The Videx Preboots

Videx sells a set of preboot disks that allow you to enhance some of the more popular software in conjunction with the Ultraterm.

The preboots are separate disk-based programs that you have to load into the Apple before you load an application program. The preboot then configures the Apple and Ultraterm to give you some special features. The preboot will first ask you to select one of several options and it sets up the Ultraterm accordingly. You then load the application program as you would normally. The preboots do not make changes to the application program, so there is no need to worry about voiding warranties or writing things to your application disks. Let's take a look at two currently available preboots.

Applewriter II/IIe Preboot

The Applewriter preboot program gives you the ability to display more than 40 columns and 24 lines. Your choices are: 80 columns by 24 lines, 80 columns by 32 lines, or 80 columns by 48 lines.

As mentioned before, you need a good monitor to use the 80-column feature. The extended displays make a big difference in how you process words. I found that the 80 by 48 display gives me a better "feel" for how my final documents will look because it is so close to the actual size of a physical page (80 by 55). Most first-time users will probably prefer the 24-line mode until they get used to the slightly smaller characters that are used with the 32- and 48-line modes.

This preboot works with either Applewriter II or IIe. Just follow the instructions on the instruction sheet.

PGS introduces the no-compromise monitor to meet your no-compromise needs.

High resolution

Once you've invested in a first-rate computer, you don't want to compromise with a second-rate monitor. That's why PGS introduced the first no-compromise monitor, the Princeton HX-12. It set the price/performance standard for high resolution RGB color monitors.

Super resolution

Now we're introducing the first no-compromise monitor in the super resolution class. It's our new SR-12: an RGB monitor that meets the most demanding expectations at a price that will surprise you.

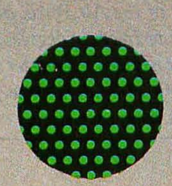
Monochrome

And, for price/performance in a monochrome monitor, we're introducing the MAX-12: our new amber monitor that's as easy on the eyes as it is on your budget.

The monitor to meet your needs

All three PGS monitors are engineered for no-compromise performance to provide you with a cleaner, sharper image than any other monitor in the same price class. The HX-12 and the SR-12 both feature uncompromising color convergence for crisp whites without color bleed. The MAX-12 offers impressive clarity in a monochrome monitor with easy-on-the-eyes amber phosphor.

And all three monitors come with a non-glare screen and a shielded cable that plugs directly into the IBM PC or XT.



The HX-12 has the highest resolution (690x240) and the finest dot pitch (.31mm) in its class. And yet its suggested retail price is comparable to many medium resolution monitors. The HX-12 brings no-compromise color to the PC and now, with the PGS RGB-80 board, to the Apple IIe as well.
Suggested retail price: $695.

The new SR-12, in conjunction with the PGS high performance color graphics card, also features a .31mm dot pitch supporting 690 horizontal resolution. However, by increasing the horizontal scan rate to 27.5 KHz, the SR-12 can support 400 vertical resolution in non-interlaced mode. This results in a very high quality, flickerless image with the ability to generate graphics and text that is truly of monochrome quality.
Suggested retail price: $799.

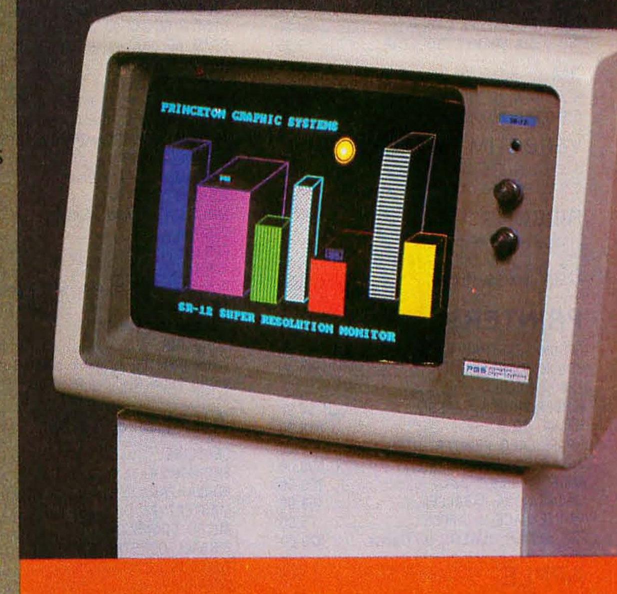
The new MAX-12 offers you easy-on-the-eyes amber with 720x350 resolution at a suggested retail price ($249) that is actually lower than the leading green-on-black competitor. And the MAX-12 runs off the IBM PC monochrome card—no special card is required.

Clarity of the Max 12 is enhanced by dynamic focusing circuitry which ensures sharpness not only in the center but also in the edges and corners.
Suggested retail price: $249.

Whatever your needs, from word processing to super resolution graphics, there's now a no-compromise PGS monitor that sets the standard. Ask your dealer for a demonstration and let your eyes decide. Or call for more information and the name of your nearest dealer.

You can look to PGS for the image your eyes deserve.

Circle 301 on inquiry card.



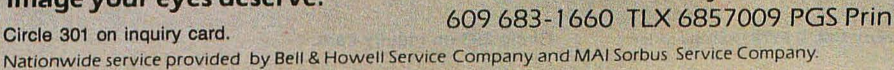
800-221-1490





Princeton Graphic Systems

1101-I State Road
Princeton, New Jersey 08540
609 683-1660 TLX 6857009 PGS Prin



There is one thing you need to about this preboot: Applewriter normally rewrites the entire screen each time you type something in. This works fine with a 40-column display, but with the Ultraterm there are many more characters, and the program really can't keep up. To resolve this, the preboot program shows the characters as they are typed. The rest of the screen is updated whenever you pause.

The Visicalc Preboot

This preboot will probably be the answer to the prayers of Visicalc users everywhere! As with the other preboot programs, you load the Visicalc preboot first, but the first time you use it, it will automatically configure itself to match your version of Visicalc (version 193, 202, 208, or 218). If you change versions the preboot can be reconfigured. This program has the following display size options: 80 columns by 24 lines, 80 columns by 48 lines, 128 columns by 32 lines, or 160 columns by 24 lines. With the 160-column option, however, you have to have a monitor that can handle the full 160 columns.

The first time I went from 40 to 80 columns and tried different line lengths I was amazed at the difference this preboot made in using Visicalc. When I went to the 128- and 160-column modes I was astounded. The added window width and height gives you a realistic idea of how your spreadsheet will look when done; it also "feels" better.

It's worth adding the Ultraterm display card to your Apple just to have access to this preboot-expanded Visicalc. It was difficult to go back to normal Visicalc after using the preboot.

Documentation

The Ultraterm manual deserves mention as one of the best I have seen. It includes a table of contents, glossary, index, overview, and installation guide, as well as separate chapters on each relevant subject area. It contains the Ultraterm's theory of operation, schematics, and firmware listings. There is even a section that lets WordStar users configure their disks to come up automatically in the 80-column by 48-line format. I wish all manuals were as complete as this one.

Conclusion

Overall, the Ultraterm display card is one of the best peripheral devices I have seen to enhance the display capabilities of the Apple. It can be used in any Apple II, including the IIe with extended memory. This display card will without a doubt make the Apple II display the new standard against which all microcomputer video displays will be measured.■

Peter V. Callamaras, an officer in the Air Force, can be reached at AFCC/EPPB, Scott AFB, IL 62225. The recipient of degrees in computer technology and biological sciences, he recently received his master's degree in systems management. He has been interested in computers since 1966 and used to be the service department manager of a computer store.

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- Printer mode software controls: baud rate, data format, delays, parity, case, column overflow, reset (the Serial-2 card), pass through (ignore 〈CTRL〉 commands) linefeed after carriage return, video echo, XON-XOFF, tab function in BASIC.
- Printer mode hardware default settings include: baud rate, interrupts, data format, parity, line-feed after carriage return, carriage return delay, line width and video echo.

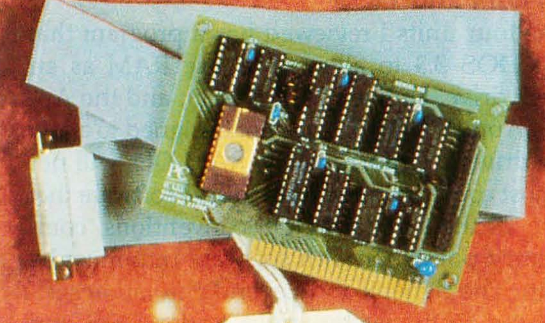
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Part No. 22010 $59.95
- With cable included

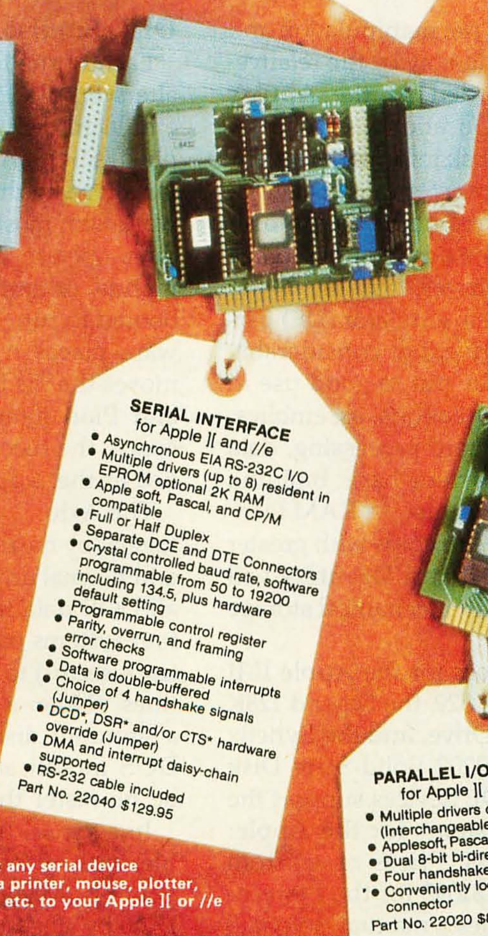
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Apple Disk Emulators: Axlon, Legend, Pion, and Synetix

Four RAM disk emulators for the Apple II allow faster execution times for certain applications

by Michael W. Gilbert

Applications that require a lot of file manipulation and disk access are often slowed considerably by the relatively slow disk-access speeds afforded by the Apple's 5¼-inch disk system. These applications, of course, would be greatly enhanced if the disk information transfer rate were brought up to the transfer rate of data in RAM (random-access read/write memory). Some user systems could also benefit from the addition of storage space in the form of more disk drives.

For most applications, a RAM disk emulator (DE) performs exactly like a mechanical drive, but considerably faster. This speed advantage can be put to good use in many applications, including compilations, assemblies, database manipulations, sorting, word processing, data acquisition, and graphics. The current basic building block of the DE is the 64K-bit RAM chip. As RAM technology is developed, we will see RAM chips with greater storage capacity and lower prices, and DE units will become even more competitive with mechanical storage methods.

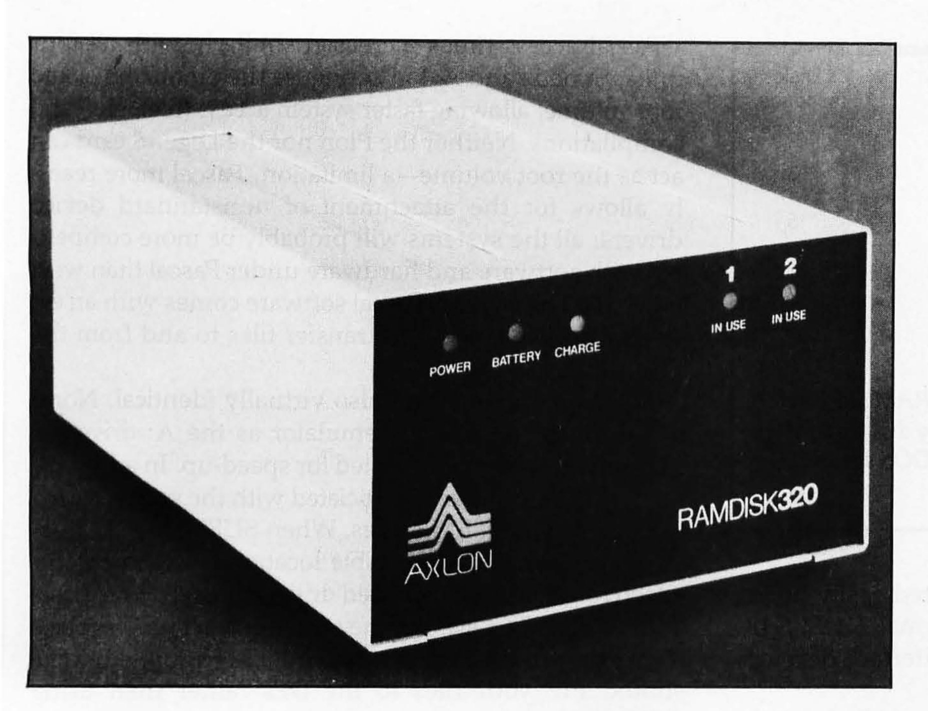
I compared four RAM DE devices for the Apple II/II Plus/IIe family: the Axlon Ramdisk 320, the Legend 128K DE Softdisk, the Pion Interstellar Drive, and the Synetix Flashcard (formerly the Synetix 2202 Solid-State Disk Emulator) (see photo 1). All four DE devices support the three most popular operating systems for the Apple: Apple DOS 3.3, Pascal, and CP/M. Prices range from $529 for the Synetix Flashcard to $1095 for the Pion Interstellar Drive. Each system includes a manual, software to interface it with the operating systems, various utilities, and a diagnostic program for the RAM chips.

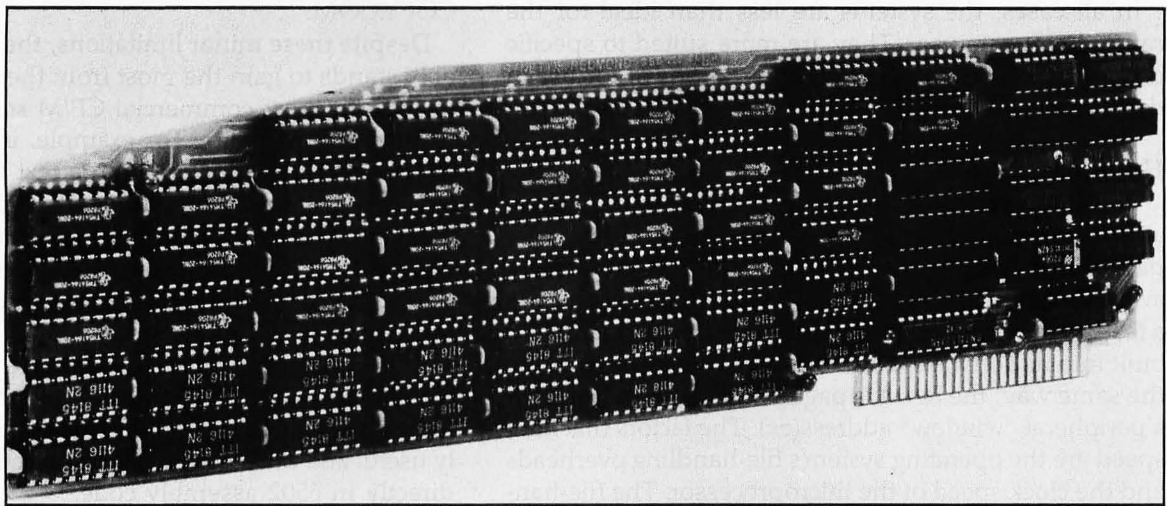
Disk Emulators and DOS

Each of the four units I reviewed has a program that alters Apple DOS 3.3 to allow it to use RAM as an emulated disk drive. Unlike CP/M, Pascal, and the Apple III's SOS, Apple's DOS 3.3 was not designed to allow for alternate drivers. Unfortunately, RAM DEs will not work with most copy-protected or modified software that does not use all the standard DOS conventions, commands, or entry points, or with software that must be booted to run. The Synetix and Legend emulation software places the DOS patches right under DOS and moves the file buffers down to protect them. The Axlon and Pion interface cards both have their own RAM space; the patches are located on the interface card and not in the Apple II main memory.

The Axlon DOS patch has an excellent feature: it can toggle (by means of a $300 routine) between Axlon DOS and normal unpatched DOS. This routine also preserves all DOS data in the lower pages (0–3) of memory. The four systems patch a routine called the RWTS (read/write track/sector) to route calls through their own access routines. (Note: a DE could be set up to look exactly like a standard disk controller to the bus, but without the DOS modifications—involving timing loops—it would be no faster than a disk.)

In a sense, the Axlon and Pion DEs will be compatible with a few more programs than the others (for example, Magic Window II), but because they all change DOS by at least 2 bytes (a Jump--JMP--operand), any program that overwrites DOS with its own operating system will obliterate the patch no matter how small it is. The





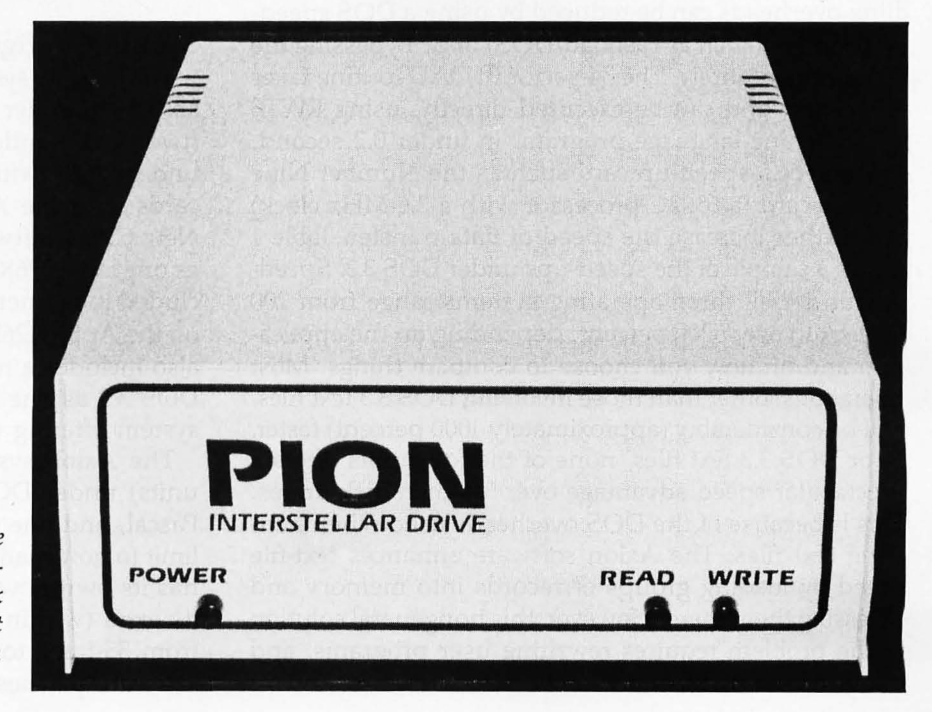


Photo 1: *RAM disk emulators for the Apple. The units shown are, top to bottom, the Axlon Ramdisk 320, the Synetix 2202 Solid State Disk Emulator, and the Pion Interstellar Drive. Not shown is the Legend 128K DE Softdisk, which somewhat resembles the Synetix card.*

Task	RAM Disk Emulator (seconds)	Disk (seconds)
BLOAD (34 sectors)	2.5	10
with Fastload	0.4	3
BSAVE (34 sectors)	3	15
LOAD (84 sectors)	6	21
with Fastload	0.7	7
SAVE (84 sectors)	7	34

Table 1: *A comparison showing how quickly a RAM disk emulator can access data compared with a normal floppy disk under Apple DOS 3.3. Performance was also tested with a DOS speed-up program called Fastload/DOS.*

Axlon DOS can, however, be reconnected easily (using the toggle) once you are back in normal DOS. This method may lend itself well to future interface developments.

In all cases, the systems are less than ideal for the canned-software user. They are more suited to specific user-written or user-modified applications or for use in development systems.

How Much Faster?

The access speed increases offered by all four units are almost exactly the same. All but the Legend are compatible with Microseeds' Fastload/DOS, a commercially available utility that speeds up DOS 3.3. The Legend has a feature that is functionally equivalent to Fastload/DOS built into its software. The units all work approximately the same way; the RAM is paged and accessed through a peripheral "window" address(es). The factors that limit speed are the operating system's file-handling overheads and the clock speed of the microprocessor. The file-handling overheads can be reduced by using a DOS speed-up program (such as Fastload/DOS) or by bypassing the file handler entirely. The 34-sector BLOAD routine takes 0.4 second and can be executed directly, using RWTS in a machine-language program, in under 0.2 second. The use of a speed-up card such as the Number Nine Booster card (a 6502C processor with a 3.6-MHz clock) can further increase the speed of data transfer. Table 1 shows a sample of the speed-ups under DOS 3.3. Speed-ups under all three operating systems range from 200 percent to over 5000 percent, depending on the application and on how you choose to compare things. Most operations, other than those involving DOS 3.3 text files, will be considerably (approximately 1000 percent) faster.

For DOS 3.3 text files, none of the four units offers a spectacular speed advantage over 5¼-inch disk drives. This is because of the DOS overheads used when handling text files. The Axlon software enhances text-file speed by loading groups of records into memory and accessing them there. However, this nongeneral solution to the problem requires rewriting user programs, and it will not work in many cases.

Pascal access times increased similarly with all four units. Synetix and Axlon configure the emulators as the root volume, allowing faster system access (filer, etc.) and compilations. Neither the Pion nor the Legend card can act as the root volume—a limitation. Pascal more readily allows for the attachment of nonstandard device drivers: all the systems will probably be more compatible with software and hardware under Pascal than with DOS 3.3. The Synetix Pascal software comes with an excellent utility (U.code) to transfer files to and from the Flashcard.

CP/M access times are also virtually identical. None of the units can use the emulator as the A: drive, so SUBMIT files cannot be tested for speed-up. In addition, the ATTACH programs associated with the systems cannot be used in SUBMIT files. When SUBMIT.COM is in effect, it changes vector table locations needed by the attach routines. The emulated drives cannot be formatted with FORMAT.COM, but they usually don't need explicit formatting (if they do, a quick utility is supplied). You should PIP your files to the DEs rather than using COPY.COM.

Despite these minor limitations, the CP/M user probably stands to gain the most from the DEs; they can be used with most commercial CP/M software with little or no incompatibility. For example, if you run a spelling-checker program on a large text file first with the 5¼-inch disk and then with a DE, the DE's usefulness is apparent. The ease with which CP/M can be reconfigured to accept I/O (input/output) code changes and new drivers to support custom I/O devices serves to highlight a weak point of the Apple DOS.

All four DEs can be accessed directly with the RWTS routine under DOS 3.3 in assembly/machine language for high-speed applications. This makes them especially useful and extremely fast for applications programmed directly in 6502 assembly code.

System Configurations

The Synetix system can emulate up to 12 drives (using six cards) under DOS 3.3, two large (560-block) drives (two cards) under Pascal, and four drives (two cards) under CP/M, with a suggested maximum of three to four cards with the Apple II Plus standard power supply. New CP/M software allows two cards to be configured as one large 576K-byte drive. In addition, utilities are included to segment and reconstruct large files for backup on the Apple 126K-byte floppy disks. The Synetix system also includes a routine to use its 294K-byte card under DOS 3.3 as one large 32-sector drive. This is the only system offering a large drive option under DOS 3.3.

The Axlon system can emulate up to 12 drives (six units) under DOS 3.3, six drives (three units) under Pascal, and one drive (one unit) under CP/M, with no limit to how many systems can be used. Each Axlon unit has its own power supply. The Axlon allows for using its extra (within the 320K-byte) RAM as an expansion from 35-track to 40-track emulation, with appropriate software patches.

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Xenix is a Trademark of Microsoft, Inc.

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At a Glance

Name
Axlon Ramdisk 320

Type
External RAM disk emulator

Manufacturer
Axlon Inc.
1287 Lawrence Station Rd.
Sunnyvale, CA 94089
(408) 747-1900

Size
8½ by 6⅛ by 3¾ inches

Features
320K bytes of memory, own power supply and battery backup, comes with two database-manager programs

Hardware Needed
Apple II or III

Documentation
75-page manual

Options
UCSD Pascal driver: $15

Price
$999

The Legend unit can emulate four drives (four cards) under DOS 3.3, four drives (four cards) under CP/M, and six drives (six cards) under Pascal. Legend Industries Ltd. is currently working on emulations of larger drives under Pascal and CP/M.

The Pion system can emulate two drives (one unit) under DOS 3.3, two drives (one unit) under Pascal, and one drive (one unit) under CP/M. The Pion system, however, can be physically expanded up to 1 megabyte of RAM (extra available in 256K-byte increments) enabling emulation of up to eight drives (one unit) under DOS 3.3 (using optional mapping software) and very large drives under Pascal (up to 1768 blocks) and CP/M.

The four units include software for initializing the emulator system (installing the patches). The Pion system requires the DE to be formatted for each operating system; this is usually done only once, after the unit has been powered down, or for a change of operating system. The Axlon system uses a configuration utility that creates a boot program to carry out particular copy operations. The Synetix system has an installation utility that is user friendly, including a prompted copy routine. The Legend system has an installation utility that assigns an emulated drive number that can be other than the slot/drive numbers, to be used by DOS enhancement copy commands. The Legend DOS enhancements add two new commands directly to DOS 3.3: MOUNT and UPDATE. The command .M1,S6,D1 copies the contents of S6,D1 5¼-inch disks onto emulated drive 1; .U1,S6,D1 copies the contents of emulated drive 1 onto a disk in S6,D1. *Under CP/M,* all the systems use similar ATTACH.COM files. Note that, because of SUBMIT's use of the vector table under CP/M, some of the ATTACH.COM files cannot be used in SUBMIT files for turnkey use. Under Pascal, all systems use similar drives that are appropriately configured and attached by the Pascal system after booting from the disk.

All of the units include software for configuring turnkey systems for initial loading and start-up.

Installation

The Axlon DE is an attractive, freestanding unit, the size, shape, and color of an Apple II Disk Drive, with a power cord and cable/interface card that installs in any Apple slot (1 through 7).

The Pion unit is also well packaged in a slightly larger metal case (to allow for RAM expansion), with an interface card that must be installed in slot 4. I have one criticism of the Pion: the power supply is a calculator type, on the plug end of the power cord, and it cannot be switched on and off. Because both the Axlon and the Pion RAM are external to the Apple, heat is not a problem.

The Legend is a compact card that installs inside the Apple in any slot. My Legend card required the removal of an Apple motherboard RAM chip and the installation of a refresh strap from card to motherboard, which may make the current version of this card incompatible with the IIe. Legend Industries Ltd. has now updated the product: the new version has its own refresh (no strap) and will work with both the IIe and the III in II emulation mode.

The Synetix is a large, tightly packed, cleanly laid out card that also installs in any Apple slot. Despite the fact that the RAM is inside the Apple, the low power con-

At a Glance

Name
Legend 128K DE Softdisk

Type
Memory card with disk-emulation software

Manufacturer
Legend Industries Ltd.
2220 Scott Lake Rd.
Pontiac, MI 48054
(313) 674-0953

Size
7¼-inch Apple expansion card

Features
128K bytes of memory, comes with several utility programs

Hardware Needed
Apple II or III

Documentation
98-page operating manual

Options
64K-byte version ($327)

Price
$599



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At a Glance

Name
Pion Interstellar Drive

Type
External RAM disk emulator

Manufacturer
Pion Inc.
101R Walnut St.
Watertown, MA 02172
(617) 923-8009

Size
9 by 8½ by 4 inches

Features
256K bytes of memory, own power supply and battery backup

Hardware Needed
Interfaces available for several computers, including Apple II, S-100-based systems, TRS-80 Models II, III, and 4, Morrow, and IBM PC

Documentation
15-page manual

Options
Extra 256K-byte memory cards ($595), up to 1 megabyte

Price
$1095

sumption (approximately 150 mA) ensures that very little heat is generated.

All four DEs are compatible with a wide range of peripherals including language cards, printer cards, serial I/O cards, Z80 cards, 80-column cards, etc. Problems will arise with alternative storage devices that use the same parts of DOS for patching and with a peripheral card that has a routine in ROM (read-only memory) that makes an absolute reference to a DOS point that has been patched or changed.

The Axlon and Pion units are self-powered; each has its own power supply and battery backup. Without this backup system, any loss of power will mean loss of stored information. The drives can be left on all the time and will retain data. In addition, in case of power failure or brownout, the drives are battery backed-up for approximately three hours (Axlon) and one-half hour (Pion), with the battery under continual trickle charge when the power is on. I tested the feature and the claimed backup times are accurate.

The self-power feature accounts, in part, for price differences between the units. The potential DE user must assess his needs with regard to the importance of data retention after power down. The feature is not needed for every DE application; the devices can be reloaded easily with data on power-up. An ideal situation would be to have the entire computer system backed up; currently, if a power outage lasts longer than the batteries, the data is lost because it can't be backed up onto a disk.

The Axlon is the only unit to store the DOS image: it can be warm booted with the command PR#*x*, where *x* is the slot number of the Axlon's interface. Because it is always powered independently from the Apple II, it can also be used as a cold-boot drive if placed in a slot numbered higher than the disk controller's slot. The ability to warm and cold boot from the Axlon gives it an advantage for certain uses. Most designers opt not to designate tracks on the emulated disks as system tracks for saving space or using it for data; in almost every case, the operating system tracks are already on the disk in the system.

Documentation and Software

The Synetix and Pion software are sparsely documented; a listing for direct access of the RAM in assembly code is included but is only briefly commented on. The package could be improved with source-code listings for the DOS patches.

The Axlon unit has well-annotated assembly-code listings of its programs, and its manual is well presented and relatively clear.

The Legend software is well documented and the software can be modified fairly easily (by a skilled assembly-language programmer).

In all cases, however, the manuals are not always clear enough, and they fail to cover aspects of use as well as problems due to software interactions with existing system conventions. All of the units come with hardware diagnostic routines that were tested by substituting known-defective RAM chips for good ones. The Synetix program is the easiest to use, but the card must be in a particular slot, an inconvenience in multicard systems.

At a Glance

Name
Flashcard (formerly Synetix 2202 SSD)

Type
RAM disk-emulator card for Apple II

Manufacturer
Synetix Micro Products
15050 N.E. 95th St.
Redmond, WA 98052
(800) 426-7412

Size
11½-inch Apple expansion card

Features
294K bytes of memory

Hardware Needed
Apple II

Documentation
30-page user's manual

Options
147K-byte card (Synetix 2201), Softech Microsystems' p-System operating system, Magicalc spreadsheet program from Artsci ($70)

Price
With 294K bytes: $529
With 147K bytes: $349

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As for applications software, both the Synetix and Pion systems come without any. The Axlon unit, however, comes with two database systems, both documented, listed, and modifiable; a utility to enable the extra 40K bytes of memory the unit has; and a utility to manipulate certain text files faster. The Legend unit is a general-purpose RAM card; as such, the disk emulation itself is, in a sense, a utility. The Legend unit comes with a complete documented set of additional utilities: Ampercard—software that enables the user to easily use the card to store and access 128K bytes of strings, arrays, and variables under BASIC; Memory Master—software that relocates DOS onto the card and out of Apple II memory and simultaneously makes available 3.2 and 3.3; Slide Select—software for rapid access of image files; Firmware Selector—software allowing the user to move a firmware Integer or Applesoft card out of slot 0; and Visicalc-Expand—to enable Visicalc users to manipulate larger (up to 176K-byte) models.

A Balance Sheet

Axlon pluses: the unit is always powered and backed up by battery, and it does not need reloading. The operating-system image is stored for cold and warm booting. It has the least amount of in-Apple memory patching due to RAM space on interface. It can toggle between Axlon DOS and normal DOS. It has good documentation (currently being revised and expanded) and a complete software package (also being expanded to include more CP/M and Pascal utilities). Minuses: it takes up physical space outside of the Apple and is expensive.

Legend pluses: the Legend is a general-purpose RAM card that can be used in many applications other than disk emulation, including use with Visicalc. It has DOS enhancements with new commands, MOUNT and UPDATE. It has excellent commented listings of software to allow for modifications and an excellent package of memory-management utilities. Minuses: it has the smallest disk-emulation capacity per card and total drives, and it has one technical problem—if a system Reset occurs during disk (emulator) access, the system will hang up, requiring a cold boot (and causing the loss of RAM-card data). [**Editor's Note:** *Legend Industries has recently released another version of its memory card, called S-Card. This card can hold from 64K bytes to 256K bytes of memory. And, when 256K-bit chips become available, the upper limit will be 1 megabyte. The price for the 64K-byte version is $399; 128K-byte, $524; and 256K-byte, $724. . . .* **R. M.**]

Pion pluses: the unit is always powered and battery backed-up, and it does not need reloading. It has the least amount of in-Apple memory patching due to RAM space on its interface. Its RAM is expandable to 1 megabyte. It has good documentation, and hardware error detection is provided to prevent faulty data. The Pion drive is the only system I evaluated that is not designed exclusively for the Apple; it can run (using different host interfaces) on Apple, S100/IEEE 696, TRS-80 II/III, IBM, SS50, Motorola, and with a universal Z80-interface Osborne, Intertec, Superbrain, Morrow, etc. It will soon be expanded to cover North Star, Victor 9000, and Dec Q bus as well. Operating systems supported include Apple (DOS 3.3, CP/M, and Pascal), CP/M 2.2 (S100), TRSDOS, LDOS, FLEX, OS-9, RT-11, and North Star DOS, soon to include CP/M 3.X, CP/M-86, concurrent CP/M, MS-DOS, TURBODOS, MP/M, and CDOS. Because of its extensive range and its capacity to expand to 1 megabyte, this device will be of interest to many users outside the Apple market. Minuses: it takes up physical space outside of Apple, its power supply is unwieldy, and it is expensive.

Synetix pluses: the Flashcard performs functionally as well as any system on the market, but at a much lower cost. It is well developed in all operating system environments. It has well-developed CP/M software and 32-sector operation in DOS 3.3. It takes up the least amount of space and is the easiest unit to install or move around. Minuses: it has inadequate documentation and not enough utility and applications software.

Conclusions

All these units perform well and are reliable. Not once during many weeks of moderate-to-heavy use did any of the units (once debugged) fail to operate correctly. They all offer about the same speed advantages and the same software incompatibility disadvantages. Axlon and Pion have a power/backup hardware advantage, but at a price. Synetix offers equivalent performance with fewer features at a lower price. Legend offers a general-purpose RAM board whose features and uses extend well beyond disk emulation.

The RAM disk emulators that I reviewed will give users a definite speed advantage over mechanical drives. Another advantage is the possibility of using DEs in environments hostile to the moving parts of mechanical drives. (One manufacturer cited systems used at a grain elevator as an example. The grain dust in the air would hopelessly jam up a disk drive after prolonged use.) I have found the DEs useful; in fact, I wrote this article with the help of one. My programs can be edited and compiled faster than they were without the DEs, my database runs and sorts much faster, and I have developed full-frame graphics animation programs that run at about seven full frames per second—no easy task on an Apple.

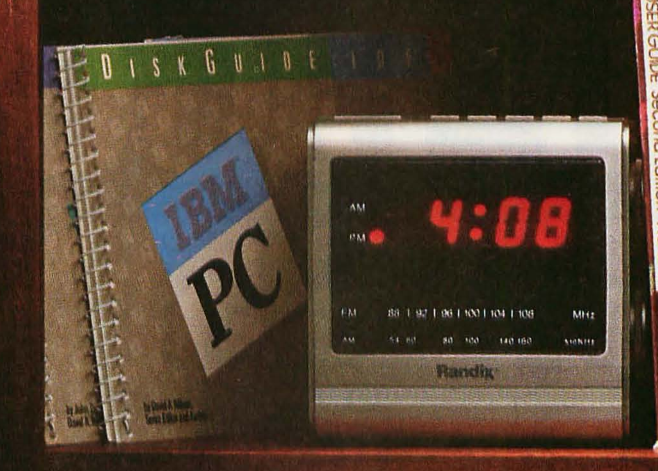
I use CP/M on my Apple almost exclusively these days. It is under CP/M that all the DEs are most compatible and, therefore, most useful.

There is no one "best" DE: each has features that make it suitable for different applications. There are differences in software, documentation, and ease of use that will be important when you evaluate a potential purchase.■

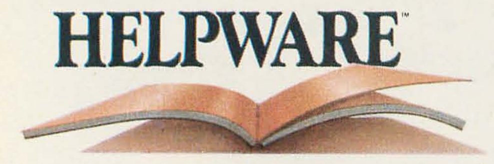
Michael W. Gilbert (73 Spaulding St., Amherst, MA 01002) is an independent microcomputer consultant, electronic music composer, and technical writer. His first contact with RAM disk emulation was as a consultant to Synetix Micro Products writing graphics demo software. His current area of computing interest is graphic art.

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IBM/Apple Communication

Sending text files between Apples and IBM PCs is easy with these simple programs

by Robert Jones

Perhaps there are some BASIC programs or files on an Apple II Plus or IIe computer that you would like to use on an IBM PC or XT without having to type them in all over again. Or maybe there is an IBM file that you would like to massage with some Apple software. The IBM PC and Apple versions of BASIC are similar enough that, with only minor modification, many programs written for the Apple II will run on the IBM PC and vice versa. In this article I will outline a method and list programs that will allow you to transfer BASIC programs or data files between IBMs and Apples quickly and easily.

These programs assume that each machine has a serial I/O (input/output) board and that a "cross-over cable" (sometimes called a "modem eliminator") links the serial boards together. A cross-over cable has connectors on each end that join pin #2 of one serial connector with pin #3 of the other machine's serial connector. This crossover of the data lines enables the data output from one machine to become the input to the other. Cross-over cables are available from computer dealers at a nomimal price.

These programs also assume that disk drives (as opposed to cassette recorders) are used on each machine and that a reasonably standard DOS (disk operating system) is being used on each system. The programs run on the IBM PC and Apple II Plus and will probably run on the IBM XT and Apple IIe as well, because no unique features of these models are used.

A Brief Overview of the Method

The user controls the operation of this data transfer from the keyboard of the receiving machine. This control is assumed once the sending machine's program begins to run. The user runs the receiving program, supplying, when asked, the name of the file to be sent from the sending machine and the name of the file under which to save it on the receiving machine. The requested file is loaded into a string array on the sending machine, sent line by line to the receiving machine's comparable string array, then the string array is saved to a file on the receiving machine's disk drive. These programs use a 4800-bps (bits per second) rate and a format of 7 data bits, 1 stop bit, and even parity. Set the parameters on the Apple serial card and use the IBM program's OPEN statement to fix them for the PC's communications buffer.

Their versions of BASIC are similar enough that, with minor modifications, many programs written for the Apple II will run on the IBM PC and vice versa.

Apple-to-IBM Example

Suppose that you have a text file on your Apple but your IBM PC has some software that plots data for you. The following instructions will send your text file from the Apple II to the IBM PC. Listing 1 is the APTOIBM sending program. Listing 2 *is the* APTOIBM receiving program. Before running these programs, be sure that the serial-card slot number for the Apple is correctly noted in the Apple II program (that is, set SLOT equal to the slot number if it is other than slot #5). Check that your IBM PC serial board is configured as COM1: as specified in the OPEN statement. COM2: can be used in the program by modifying the OPEN statement. Make sure that there is sufficient disk space in the receiving machine.

Run the program on the (sender) Apple II first. The message "Waiting for instructions from the IBM..." should appear. Be sure that the file to be transmitted is on the disk in one of the Apple drives. Now run the IBM (receiver) program. When asked for the Apple filename, enter the name as it appears in the catalog of that disk, including the drive specification, if needed (e.g., "MYFILE,D2"). You will also be asked for the filename under which to save this file on the IBM PC. Be sure to give it a valid

filename specification (e.g., "B:MYFILE.DAT"). After pressing the *Return* key, you should see the Apple's drive light go on as it searches for the requested file. As the file is being transferred, it will be listed on the Apple's screen. When transmission is completed, the lengths of the string arrays (containing the "lines" of the files) in both machines will be compared. If the lengths match, then the IBM will save the file. If the lengths do not match, then you will be asked to either save the file or abort it. Over 90 percent of the time, the lengths will match. If they do not, there may have been a leading or trailing blank space in one or more of the lines or control characters within the text. I would suggest saving the transferred file anyway, then later searching for the cause of the problem. I have not yet had a discrepancy with a Visicalc file nor with a text file containing only alphanumeric characters (such as those written with an Applesoft WRITE statement). The files created by word-processing programs are another story, however. These are best saved (despite any length discrepancies) and edited later.

If the file to be transferred is not found on the sending machine, then the user is informed and asked to enter the correct filename. The program may be halted by pressing the Return key instead of specifying a filename. If the requested file can't be found, check the drive specification and the spelling of the filename and run both programs again.

If the file contains more than the 2000 lines for which X$() is dimensioned in all programs, then dimension the X$() arrays in both programs to a larger size. A dimensioned size of 2000 "lines" is probably more than adequate for a file that fits into 25 to 35K bytes of available memory. If the file is too large to fit into the memory available, you will receive an OUT OF MEMORY message on the sending machine, and some major modification of both programs may be needed. Alternatively, you could break the file into smaller segments, transmit the segments separately, then rejoin them.

Listing 1: *The Apple to IBM sender program.*

```
100  REM   APTOIBM     SENDING PROGRAM FOR APPLE  -- LISTING #1
110  REM     BY  ROBERT JONES    AUGUST 3, 1983
120 :
130  HOME
140 :
150  REM   SOME DEFINITIONS
160  DIM X$(2000)
170 SLOT = 5: REM  SERIAL PORT SLOT
180 D$ =  CHR$ (4)
190 EF$ = "XX"
200 OE = 1
210 :
220 :
230 LI = 768: REM  LINE INPUT ROUTINE
240  FOR I = 768 TO 812: READ X: POKE I,X: NEXT I
250 :
260  REM  GET NAME FROM IBM
270  GOSUB 800
280  PRINT D$;"IN#";SLOT: INPUT FA$: PRINT D$;"IN#0"
290  PRINT
300  IF FA$ = "" THEN 760
310 :
320  REM  READ APPLE FILE FROM DISK
330  PRINT D$;"OPEN ";FA$
340  PRINT D$;"READ ";FA$
350  ONERR  GOTO 380
360 I = 0
370 I = I + OE: CALL LI,X$(I): GOTO 370
380  PRINT D$;"CLOSE": POKE 216,0:ER =  PEEK (222)
390 :
400  IF  PEEK (222) = 5 THEN 490: REM  END OF FILE FOUND
410 :
420  REM  ERROR REPORT
430  PRINT D$;"PR#";SLOT: PRINT "ERROR": PRINT D$;"PR#0"
440  IF ER = 107 THEN  PRINT "X$() IS TOO SMALL FOR FILE."
450  IF ER = 77 THEN  PRINT "FILE TOO LARGE FOR AVAILABLE MEMORY."
460  IF ERR = 176 THEN  ONERR  GOTO 380: GOTO 370: REM  LINE TOO LONG
470  GOTO 770
480 :
490 N = I - 1
500 :
510  REM   N<1 MEANS FILE NOT FOUND.
520  IF N > 0 THEN 540
530  PRINT D$;"PR#";SLOT: PRINT "NF": PRINT D$;"PR#0": GOTO 270: REM  NF
540 :
550  REM  SEND FILE TO IBM
560  PRINT D$;"PR#";SLOT
570  PRINT "FOUND"
580 AC = 0
590  FOR I = 1 TO N
600  PRINT X$(I)
610 AC = AC +  LEN (X$(I)): REM  APPLE CHECKSUM
620  NEXT I
630 :
640  REM  SEND END OF FILE FLAG TO IBM
650  PRINT EF$
660 :
670  REM  SEND CHECKSUM FROM APPLE
680  PRINT AC
690  PRINT D$;"PR#0"
700 :
710  PRINT : PRINT "WAITING FOR ANSWER FROM IBM. . ."
720  PRINT D$;"IN#";SLOT: INPUT ANS$: PRINT D$;"IN#0"
730  IF ANS$ = "MORE" THEN 270
740 :
750  REM  FINISH UP
760  PRINT : PRINT "NORMAL COMPLETION."
770  END
780 :
790  REM  SUBROUTINE FOR HEADING
800  HOME : HTAB 10: PRINT "APPLE TO IBM SENDING PROGRAM": PRINT
810  PRINT "WAITING FOR FILE NAME FROM IBM . . .": PRINT
820  RETURN
830 :
840  REM  LINE INPUT AT 768 - 812 (CALL 768, ANY$)
850  DATA   32,190,222,32,227,223,162,0,32,117,253,134,253,32,57,213,165
860  DATA   253,32,82,228,162,0,160,2,32,226,229,160,0,165,253,145
870  DATA   131,200,165,111,145,131,200,165,112,145,131,96
```

The FILE NOT FOUND, SUBSCRIPT OUT OF RANGE, and OUT OF MEMORY errors are the only major problems I have encountered in the six months I have been using these programs. However, I am sure that other errors could be encountered—there is always at least one more bug.

IBM-to-Apple Example

To send a file from an IBM PC to an Apple, see listings 3 and 4. Listing 3 is the IBMTOAP sending program. Listing 4 is the IBMTOAP receiving program. Run (first) the sending program on the IBM PC; then run the receiving program on the Apple. The operation is analogous to that of

Text continued on page 338

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Listing 2: *The Apple to IBM receiver program.*

```
100 REM APTOIBM    RECEIVING PROGRAM FOR IBM  -- LISTING #2
110 REM BY ROBERT JONES    AUGUST 3, 1983
120 :
130 REM SOME DEFINITIONS
140 DIM X$(2000)
150 EF$ = "XX": REM END-OF-FILE FLAG
160 ONE = 1
170 :
180 WIDTH 40
190 ON ERROR GOTO 710
200 OPEN "COM1:4800,E,7,1" AS #1 : REM SERIAL PORT
210 :
220 CLS: LOCATE 1,7: PRINT "APPLE TO IBM TRANSFER PROGRAM": PRINT: PRINT
230 PRINT "BE SURE THAT THE APPLE PROGRAM"
240 PRINT "IS RUNNING BEFORE YOU CONTINUE!": PRINT
250 INPUT "APPLE FILE NAME ";FA$
260 IF FA$ = "" THEN PRINT #1,FA$ : GOTO 660
270 INPUT "IBM FILE NAME    ";FI$
280 PRINT
290 IF FI$ = "" THEN FI$ = FA$
300 :
310 PRINT #1,FA$: REM TELL APPLE THE FILE TO FIND
320 FOR J = 1 TO 750:NEXT J
330 INPUT #1, NF$: REM SEE IF APPLE HAS FOUND IT
340 IF NF$= "NF" THEN PRINT "FILE NOT FOUND...REENTER NAME": GOTO 250
350 IF NF$ = "FOUND" THEN GOTO 390
360 GOTO 660: REM ANY OTHER RESPONSE FROM APPLE
370 :
380 REM  READ FILE FROM APPLE
390 PRINT: PRINT "READING FILE FROM APPLE . . .":PRINT
400 I = 0: REM INITIALIZE COUNTER
410 I = I + ONE: LINE INPUT #ONE, X$(I) : IF X$(I) <> EF$ THEN 410
420 INPUT # ONE, AC: REM APPLE'S CHECKSUM
430 N = I - 1: REM DROP THE END-OF-FILE SIGNAL FROM THE LIST
440 :
450 REM  COMPUTE LENGTH FOR CHECKSUM COMPARISON
460 PRINT "NUMBER OF LINES: ";N
470 PRINT
480 PRINT "APPLE LENGTH:",AC
490 PRINT "IBM LENGTH  :",
500 IC = 0: FOR I = 1 TO N: IC = IC + LEN(X$(I)): NEXT I
510 PRINT IC
520 IF IC= AC THEN 560: REM IF CHECKSUMS MATCH
530 INPUT "CHECKSUM ERROR, CONTINUE? ";CN$:IF CN$ <"Y" THEN 650
540 :
550 REM SAVE FILE TO I.B.M. DISK
560 OPEN FI$ FOR OUTPUT AS #2
570 FOR I = 1 TO N: PRINT #2, X$(I): NEXT I: CLOSE #2
580 :
590 REM ANOTHER FILE?
600 PRINT: PRINT "DO YOU WANT ANOTHER FILE ";: INPUT ANS$
610 IF ANS$ < "Y" THEN GOTO 650
620 PRINT #1, "MORE": GOTO 220
630 :
640 REM FINISH UP
650 PRINT #1, "NO"
660 CLOSE #1
670 PRINT: PRINT "NORMAL COMPLETION"
680 END
690 :
700 REM ERROR HANDLER
710 IF ERR = 24 THEN RESUME: REM AVOID TIMEOUT
720 PRINT "STOPPED BY ERROR NUMBER";ERR;"    IN LINE ";ERL
730 CLOSE #1
740 STOP
```

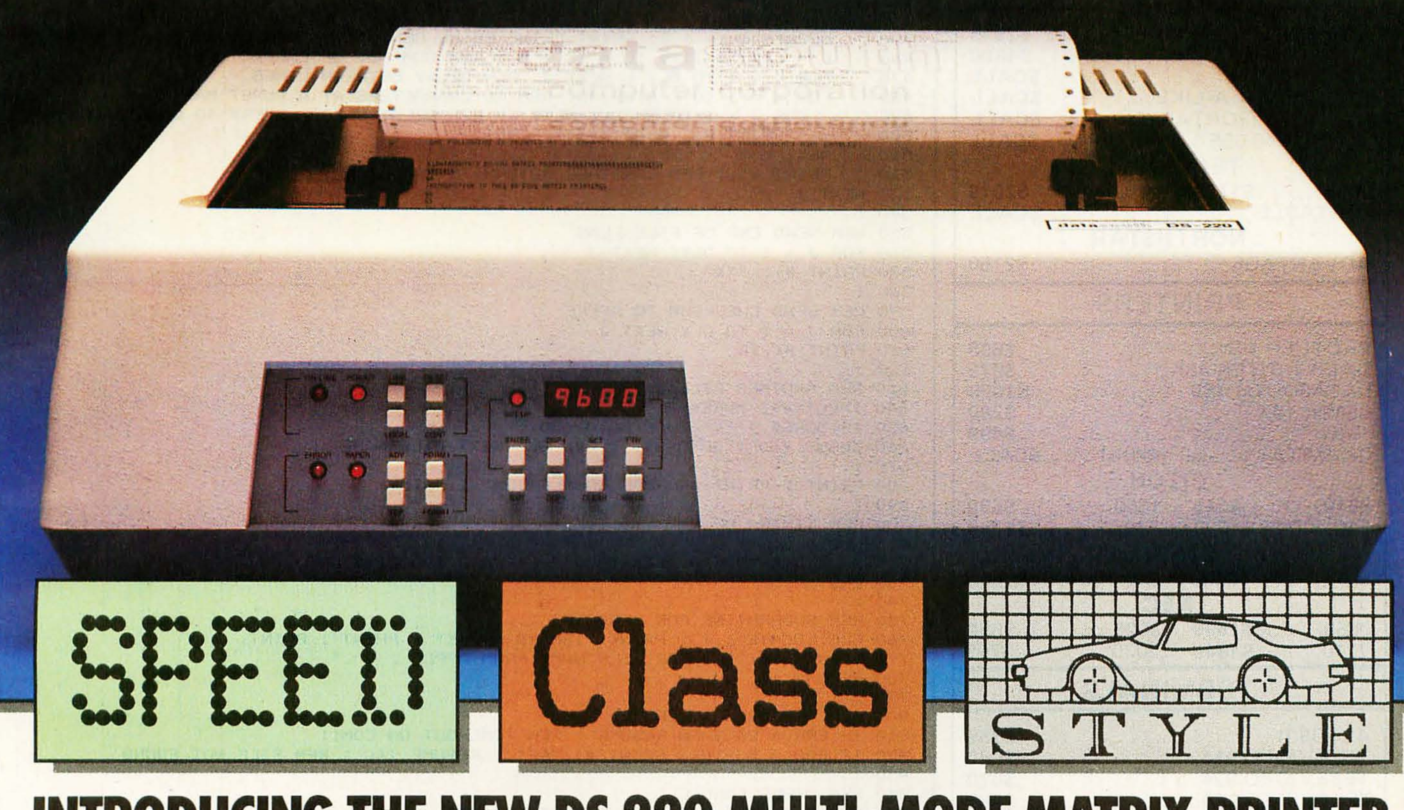
Listing 3: *The IBM to Apple sender program.*

```
100 REM IBMTOAP      SENDING PROGRAM FOR IBM  -- LISTING #3
110 REM  BY  Robert Jones    AUGUST 3,1983
120 :
130 REM  SOME DEFINITIONS
140 DIM X$(2000)
150 EF$ = "XX": REM END OF FILE FLAG
160 DLY = 500: SHDLY = 50 : REM DELAY BETWEEN LINES AND AFTER 40 CHARS.
170 ONE = 1
180 :
190 WIDTH 40: GOSUB 760
200 ON ERROR GOTO 800
210 OPEN "COM1:4800,E,7,1" AS #1: REM SERIAL PORT
220 :
230 REM  GET FILE NAME FROM APPLE
240 INPUT #1,FI$
250 IF FI$ = "" THEN GOTO 680
260 OPEN FI$ FOR INPUT AS #2
270 :
280 REM SEND FILE TO APPLE
290 PRINT #1, "FOUND"
300 :
310 REM READ FILE FROM I.B.M. DISK
```

Listing 3 continued on page 336

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Listing 3 continued:

```
320 I = 0
330 IF EOF(2) THEN 350
340 I = I +ONE: LINE INPUT #2, X$(I): GOTO 330
350 CLOSE #2
360 N = I
370 :
380 REM SEND FILE TO APPLE
390 PRINT
400 PRINT "SENDING";N;"LINES TO APPLE . . ."
410 CL = CSRLIN
420 IC = 0
430 :
440 FOR I = 1 TO N
450    LOCATE CL + 1,1: PRINT "LINE BEING SENT:"; I: REM LINE COUNT TO SCREEN
460    L = LEN(X$(I)): IC = IC + L : REM SUM NO. OF CHARACTERS
470    FOR J = 1 TO DLY : NEXT J: REM DELAY BETWEEN LINES
480    FOR K = 1 TO L STEP 40: REM 40 CHARACTERS AT A BURST MAXIMUM
490      FOR J = 1 TO SHDLY: NEXT J: REM DELAY BEFORE EVERY 40 CHAR. BURST
500         PRINT #1, MID$(X$(I),K,40);
510    NEXT K
520    PRINT #1,: REM CARRIAGE RETURN TO END LINE
530 NEXT I
540 :
550 REM SEND END OF FILE FLAG
560 FOR J = 1 TO DLY: NEXT J
570 PRINT #1, "XX"
580 :
590 REM SEND CHECKSUM TO APPLE
600 FOR J = 1 TO DLY:NEXT J
610 PRINT #1,IC
620 :
630 REM ANOTHER FILE
640 INPUT #1, MORE$
650 IF MORE$ < "Y" THEN GOTO 680
660 GOSUB 760 : GOTO 240 : REM GET NEXT FILE NAME
670 :
680 PRINT : PRINT "NORMAL COMPLETION" : PRINT
690 :
700 REM FINISH UP
710 CLOSE #1
720 ON ERROR GOTO 0: REM TURN THE ERROR TRAPPING OFF
730 END
740 :
750 REM SUBROUTINE FOR HEADING
760 CLS:LOCATE 1,13: PRINT "IBM TO APPLE" : PRINT : PRINT
770 PRINT "WAITING FOR FILE NAME FROM APPLE . . ."
780 RETURN
790 :
800 REM  ERROR HANDLER
810 IF ERR = 24 THEN RESUME : REM TIME-OUT ON COM1:
820 IF ERR = 53 THEN PRINT #1,"NF" : RESUME 240 : REM FILE NOT FOUND
830 :
840 REM OTHER ERRORS
850 PRINT "ERROR ";ERR;"   IN LINE ";ERL
860 PRINT #1, "ERROR ";ERR : REM LET APPLE KNOW
870 GOTO 710
```

Listing 4: *The IBM to Apple receiver program.*

```
100  REM     IBMTOAP   APPLE RECEIVING PROGRAM -- LISTING #4
110  REM     BY  ROBERT JONES    AUGUST 3, 1983
120 :
130  REM  SOME DEFINITIONS
140  DIM X$(2000)
150 SLOT = 5: REM  SERIAL PORT SLOT
160 D$ =  CHR$ (4)
170 EF$ = "XX": REM  END-FILE FLAG
180 OE = 1
190 :
200 LI = 768: REM   LINE INPUT ROUTINE
210  FOR I = 768 TO 812: READ X: POKE I,X: NEXT I
220 :
230  HOME : PRINT "IBM TO APPLE RECEIVING PROGRAM": PRINT
240 :
250  REM   SEND FILE NAME TO I.B.M.
260  PRINT "NAME OF I.B.M. FILE >";
270  CALL LI,FI$
280  IF FI$ = "" THEN 330
290  PRINT "APPLE FILE NAME ";
300  CALL LI,FA$
310  IF FA$ = "" THEN FA$ = FI$
320  PRINT
330  PRINT D$;"PR#";SLOT: PRINT FI$
340  IF FI$ = "" THEN  PRINT FI$: PRINT D$;"PR#0": GOTO 780
350  PRINT D$;"PR#0"
360 :
370  REM   GET RESPONSE FROM IBM
380  PRINT D$;"IN#";SLOT
390  INPUT ER$: IF ER$ = "FOUND" THEN 470
400  PRINT D$;"IN#0"
410  PRINT
420  IF ER$ = "NF" THEN  PRINT "FILE NOT FOUND.": GOTO 260
```

Listing 4 continued on page 338

Listing 4 continued:

```
430  PRINT "CHECK IBM FOR ERROR MESSAGE."
440  STOP
450 :
460  REM   READ FILE INTO X$() UNTIL END FLAG
470  PRINT
480 I = 0
490 I = I + OE: CALL LI,X$(I): IF X$(I) <   > EF$ THEN 490
500  INPUT IC: REM  CHECKSUM FROM IBM
510  PRINT D$;"IN#0"
520 N = I - 1: REM  ELIMINATE END OF FILE FLAG
530  PRINT
540 :
550 AC = 0
560  REM  COMPUTE NUMBER OF CHARACTERS RECEIVED
570  FOR I = 1 TO N:AC = AC +  LEN (X$(I)): NEXT I
580  PRINT "IBM CHECKSUM =    ";IC
590  PRINT "APPLE CHECKSUM = ";AC
600  PRINT
610  IF IC = AC THEN 680
620 :
630  PRINT "CHECKSUMS DO NOT MATCH."
640  INPUT "CONTINUE ANYWAY ?";CA$
650  IF CA$ =  > "Y" THEN 670
660  PRINT : GOTO 720
670  REM  SAVE FILE TO APPLE DISK
680  PRINT D$;"OPEN ";FA$
690  PRINT D$;"WRITE ";FA$
700  FOR I = 1 TO N: PRINT X$(I): NEXT I
710  PRINT D$;"CLOSE"
720  PRINT "ANOTHER FILE ";
730  INPUT ANS$
740  PRINT D$;"PR#";SLOT: PRINT ANS$: PRINT D$;"PR#0"
750  IF ANS$ =  > "Y" THEN 230
760 :
770  PRINT
780  PRINT "NORMAL COMPLETION"
790  END
800 :
810  REM  LINE INPUT AT 768 - 812 (CALL 768, ANY$)
820  DATA   32,190,222,32,227,223,162,0,32,117,253,134,253,32,57,213,165
830  DATA   253,32,82,228,162,0,160,2,32,226,229,160,0,165,253,145
840  DATA   131,200,165,111,145,131,200,165,112,145,131,96
```

Text continued from page 332:

sending files in the opposite direction (outlined previously) except that the transmission time is about one-third as fast because of the delays Applesoft needs to process each string before receiving the next one. In fact, if a line contains more than 40 characters, a slight delay is needed while the Apple's cursor returns to the left side of its 40-column screen. Delay loops (e.g., FOR J = 1 TO DLY: NEXT J) are inserted in the appropriate places in the IBM sending program.

I have tried to keep these programs short and straightforward so that you can easily tailor them to your own needs. Presumably, similar programs could be written to transmit files between different microcomputers with similar serial connections.

Notes on Using the Programs

1. Sending an Applesoft program to the IBM PC requires that the program first be converted into a text file. The following is a one-line routine, entered as line number 0 (zero), to save the Applesoft program in memory as a text file suitable for transmitting to the IBM PC. Type it in, then type RUN. You will be asked to name the text file for your Applesoft program.

```
0 D$ = CHR$(4): INPUT
"TEXTFILE NAME ]";F$:
POKE 33,33: PRINT D$;"OPEN";
F$:PRINT D$; "WRITE";F$:
LIST 1 – :PRINT D$;"CLOSE":
POKE 33,40: END
```

Similarly, an IBM PC BASIC program can be saved with the "A" option so that it is stored in ASCII format instead of the tokenized form, e.g., use SAVE "MYFILE",A.

2. If you are transmitting the Visicalc file from the Apple to the IBM PC, the direction indicator needed for the Apple II Plus version of Visicalc will cause a problem (i.e., horizontal or vertical movement on the arrow keys). This information is stored near the end of the Visicalc file as either "/X!" or "/X–". It must be deleted before you attempt to load it into the IBM version of Visicalc. Failure to delete this command could cause a loss of data in the cell in which the cursor is positioned when the file is loaded by IBM PC Visicalc.

3. To transfer a random-access file, I suggest first converting the data in the random-access file to a sequential file, transmitting the sequential file, then converting the data back into random-access form.

4. The monitor routine used by the Apple II Plus converts lowercase letters to uppercase letters. This conversion presents a problem if maintaining lowercase is desired. One way around this is to write your own input routine in machine language. A simpler way, if you have a language card, is to move the monitor (and Applesoft) to the RAM (random-access read/write memory) card, eliminate the conversion switching, then run the program. On an Apple II Plus with a 16K-byte RAM card in slot 0, these changes are accomplished as follows:

CALL –151	to enter the monitor
C081 C081	read ROM (read-only memory) and write to RAM
D000[D000.	
FFFFM	copy Applesoft and monitor to RAM card
C083 C083	select the RAM card
FD82: EA	
EA	delete the lower-case conversion
3DOG	warmstart DOS

Users who are familiar with EXEC files may want to create one with these commands in it. If you press Reset on the Apple, then ROM Applesoft (with the lowercase to uppercase conversion reinstalled) again takes over. To return to the modified RAM monitor, just type PRINT PEEK (–16256).

5. Interested persons may want to add routines to handle other errors or long files. A large file, for example, could be read and transmitted in blocks of 1000 lines, with appropriate delays for loading and saving to disk between blocks.

6. More memory for holding a file can be obtained on the Apple by using one of the DOS moving programs to relocate DOS to the RAM card (as long as you are not using the

RAM card for the monitor modification mentioned in #4). A file as long as 35K bytes may be transmitted in this manner. Ordinarily, 50K bytes of memory are available to IBM PC BASIC with this program in memory if 96K bytes or more are installed in the IBM. So the Apple's memory size is the limiting factor on the maximum file (or segment) size that can be transmitted. Remember that a 35K-byte Apple file shows up as a 142-sector file on a catalog of an Apple disk.

7. Although a bps rate of 4800 is used in the programs listed here, the Apple-to-IBM transfer could run at 9600. The 4800 limit is imposed by the rate at which the Apple II can receive data using these programs. If the few minutes of speed gain from the Apple to the IBM is worth the time spent setting up the Apple serial card for the faster bps rate, then the IBM receiving program could use a 9600 (instead of a 4800) bps rate in the OPEN statement. However, you would have to reset the Apple serial card to 4800 again if you were going to pass programs from the IBM to the Apple. The constant switching of bps rates is probably not worth the effort unless it can be done within the Apple programs themselves. The manual for the serial card that I use does not explain how to do this on the Apple.

8. Because Applesoft does not have a LINE INPUT statement (which allows commas and semicolons to be included in a string being read), both Applesoft programs use a short machine-language routine (located at 768 decimal) to simulate LINE INPUT. The routine used here is slightly modified from "The Penultimate Input Anything Routine" by Peter Meyer, published in *Call—A.P.P.L.E. In Depth 1: All About Applesoft*, a publication of Apple Pugetsound Library Exchange, 21246 68th Ave. S., Kent, WA 98032. ■

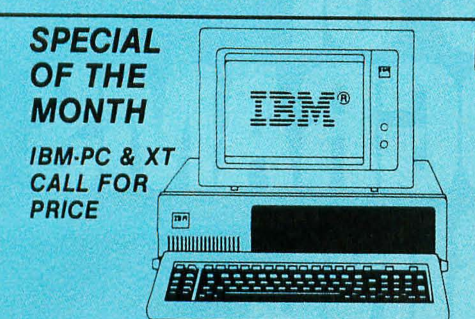
Robert Jones (7 Lexington Rd., Saratoga Springs, NY) has been using an Apple II Plus since 1979 and an IBM PC since early 1983 for statistical analysis, financial modeling, and development of simulation models of economic and social systems in BASIC and FORTRAN.

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92P	92S
93P	93S

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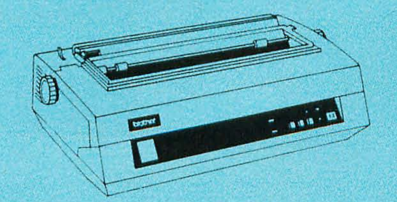
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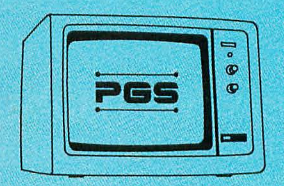
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by Joe D. Blagg

If you need nonvolatile memory, a PROM (programmable read-only memory) gives you what you need at low cost. Unfortunately, you can program a PROM chip only once. It is possible to reprogram EPROMs (erasable PROMs), but first they need to be erased with expensive ultraviolet-light devices. EEPROMs (electrically erasable PROMs) do not need ultraviolet light. Instead, they are erased and reprogrammed with high voltages (usually between 20 and 30 volts). But another problem arises here—if you want to reprogram the EEPROM, you have to remove it from your circuit and put it in a special EEPROM "burner" that has the proper voltages. This happens because most personal computers don't have power supplies with 20- to 30-volt (V) ranges. You can, of course, build a burner into your computer, as Louis Wheeler did in "The Practical EEPROM" (July 1983 BYTE, page 460).

But what a chore. It would be much easier if you could program the EEPROM without such high write-voltages and without taking the EEPROM out of your computer. With that capability, you could easily store programs or data in your computer indefinitely.

Fortunately, Seeq Technology of San Jose, California, has created such an EEPROM—the 52B13, part of the 52BXX family of EEPROMs (or E²ROMs, as Seeq calls them). The 52B13 is programmed with a TTL-level voltage and, on top of that, costs only about $10. I paid $6 for a preproduction sample chip, which is a tenth of the cost of the Intel 2817 EEPROM.

Simple Interfacing

The 52B13 is a 2K by 8-bit EEPROM that is pin for pin compatible with the popular 2716 EPROM as well as the 6116 static RAM (random-access read/write memory).

Since my Z80-based personal computer uses 6116 static memory, I was able to plug the 52B13 into one of the 24-pin memory sockets. I needed to make only one small circuit change to create a 10-millisecond (ms) write-enable ($\overline{\text{WE}}$) input to the 52B13. To create the $\overline{\text{WE}}$ signal, I "stretched out" the write signal from the processor with a monostable multivibrator or "one-shot," as it is commonly called.

The read cycle of the 52B13 does not require any special circuitry. Even with a 4-MHz clock rate, the 52B13 needs no wait states, because it boasts a 250-nanosecond (ns) maximum read access time (some versions are rated for 350 ns). The number of read cycles is unlimited, but the number of write cycles is limited to 10,000 per byte. As you might expect, a write cycle is much slower than a read cycle. The limitations for writing to the 52B13 are a small price to pay, though, for the advantage of nonvolatile memory.

The Circuit

The 52B13 needs proper address decoding, as any memory chip does. My computer decodes addresses with a 74LS138 decoder/demultiplexer, as figure 1 shows. Each of the eight output lines of the decoder goes to the different chip-enable inputs of the separate 2K memory devices.

The 74LS123 one-shot stretches out the $\overline{\text{WR}}$ signal from the Z80 microprocessor to 10 ms because the $\overline{\text{WE}}$ input of the 52B13 must remain low during the 10-ms write cycle. (By the way, the 10-ms time is a nominal period that may actually be anywhere from 9 ms to as long as 70 ms. If you need a faster write time, Seeq has a higher-performance version, the 52B13H, that can be programmed in 1 ms.) The resistor-capacitor combination causes the one-shot to stay on for 10 ms. The entire chip could be cleared in a single step, but with the 52B13 this requires a +15- to +22-V pulse. I did not experiment with this feature of the device.

Switch SW1 lets you protect the EEPROM from accidental writing. The switch should be closed when you're programming the device and open after you have finished writing to it.

Programming the 52B13

Programming the 52B13 is simple. After constructing the circuit shown in figure 1, I used BASIC commands to put data into the 52B13 and then checked to see if I was successful. It was a pleasure to see the EEPROM and its support circuitry work the first time. But why not, since the interface is so simple? Turning the power on and off did not change the contents of the EEPROM. All seemed to be well.

Then I tried to change one of the memory locations that I had previ-

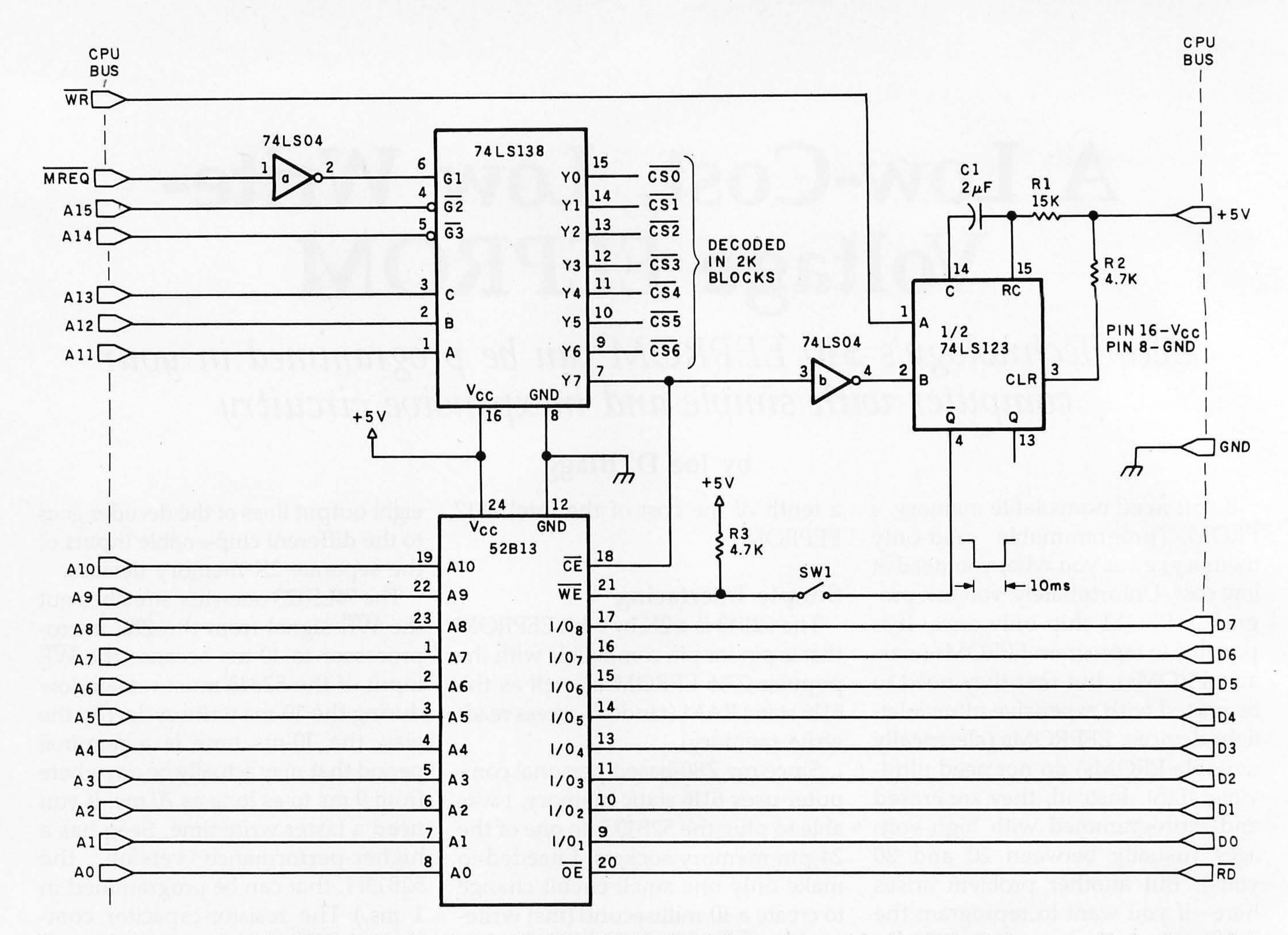


Figure 1: *A schematic of the 52B13 EEPROM circuit. The EEPROM is decoded the same as the other 2K by 8-bit memory blocks. A one-shot provides the 10-ms write-enable pulse needed for the EEPROM to be programmed.*

Listing 1: *This BASIC routine moves data from RAM to the EEPROM.*

```
100  REM ** E2ROM PROGRAMMER **
110  REM
120  REM D = STARTING ADDRESS OF
130  REM     DATA TO PROGRAM.
140  REM N = NUMBER OF BYTES - 1.
150  REM P = E2ROM STARTING ADDRS.
160  REM
170  LET  D = 0
180  LET  N = 2047
190  LET  P = 14336
200  REM
210  FOR  I = D TO D+N
220  IF PEEK (P) = 255 THEN GO TO 260
230  POKE P, 255
240  FOR J = 1 TO 2
250  NEXT J
260  POKE P, PEEK (I)
270  NEXT I
280  REM
290  PRINT "DONE"
300  STOP
```

ously put data in using POKE. To my dismay, the memory-byte contents did not change. That is when I learned that, unlike with the 2817 EEPROM, you cannot write to a memory address in the 52B13 until it is first erased, which you do by writing all logical highs to the address. When you first get the 52B13, you'll notice that all bits have already been set to a logical high state.

I wanted to try programming the full 2K bytes, so I wrote the program in listing 1. The routine first checks to see if the byte is cleared before attempting to write the data. The FOR. . .NEXT loop at lines 240 and 250 provides a time delay before the next POKE statement is executed; this delay permits the $\overline{WE}$ signal to time out before another byte is written. The entire 2K-byte transfer takes about 150 seconds to execute.

Conclusion

My original reason for using the 52B13 was to store a text-editing routine in my personal computer as a resident program. Now that I have some experience with the 52B13, I am looking forward to adding a host of resident utility programs to my system.

The age of the EEPROM seems to be upon us. Major advances in the last year have made them a cost-effective alternative to EPROMs in many areas. We can expect to see more and more of them in the future.■

References

1. Wheeler, Louis. "The Practical EEPROM." BYTE, July 1983, page 460.
2. *52B13–Electrically Erasable ROM* (preliminary data sheet). San Jose, CA: Seeq Technology Inc., March 1983.

Joe Blagg has been an instrument engineer at Union Carbide for six years. Before that, he was an electronics field engineer for the Federal Aviation Administration. He is a 1974 graduate of the University of Kentucky, where he earned his B.S.E.E. degree. His special interest is personal computer hardware and software. You can contact him at RR 13, Box 556, Paducah, KY 42001.

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Foot^Control

Adding a foot-operated Control key to your keyboard simplifies control sequences

by Dennis M. Pfister

Wordstar is a nice piece of software, but its nifty editing features are hampered because you must use too many simultaneous key strokes or control characters to implement the features. You generate them either by simultaneously pressing the Control key and a particular alphabetic character, by selecting from a group of additional keys with dedicated editing functions, or by using a mouse.

These methods work, but they all have one serious deficiency: they require you to move your hands from the standard typing position. This is inefficient and provides you with more opportunity for error.

I thought that there must be a better way. I had done a considerable amount of commercial sewing, where a foot switch is used to free the operator's hands, so I decided that this approach might be just the thing. This idea developed into what I have termed Foot^Control, which is an inexpensive (less than $40) solution for relief from all those control characters.

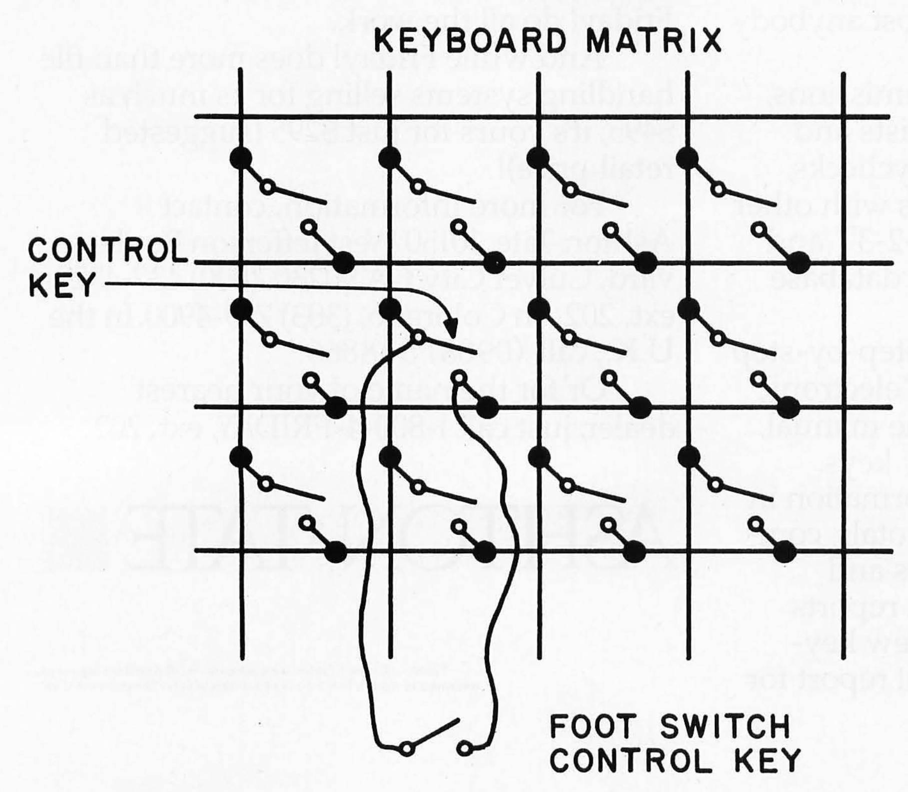


Figure 1: *A schematic of a typical keyboard matrix showing a foot switch Control key addition.*

What Does It Do?

Foot^Control gives you an additional Control key that is located on the floor and operated by foot. This allows your hands to remain in the standard typing position. You generate a control character by pressing the foot switch and then typing the desired character key. It can also be used as a duplicate ESCape key for software requiring large numbers of ESC sequences.

What You Need

The only parts required are a reasonable quality foot switch with a set of normally open contacts, a phone jack and plug, and a length of two-conductor wire. The length of wire is determined by where you intend to locate the foot switch. The plug and jack are necessary only if you want to be able to remove the foot switch.

I have used many types of foot switches and found that the heavier commercial-grade units tend to stay in place on the floor better than the cheaper ones. Second-hand switches from old office equipment work especially well. They also provide a better feel and will allow you to rest your foot on them without accidental

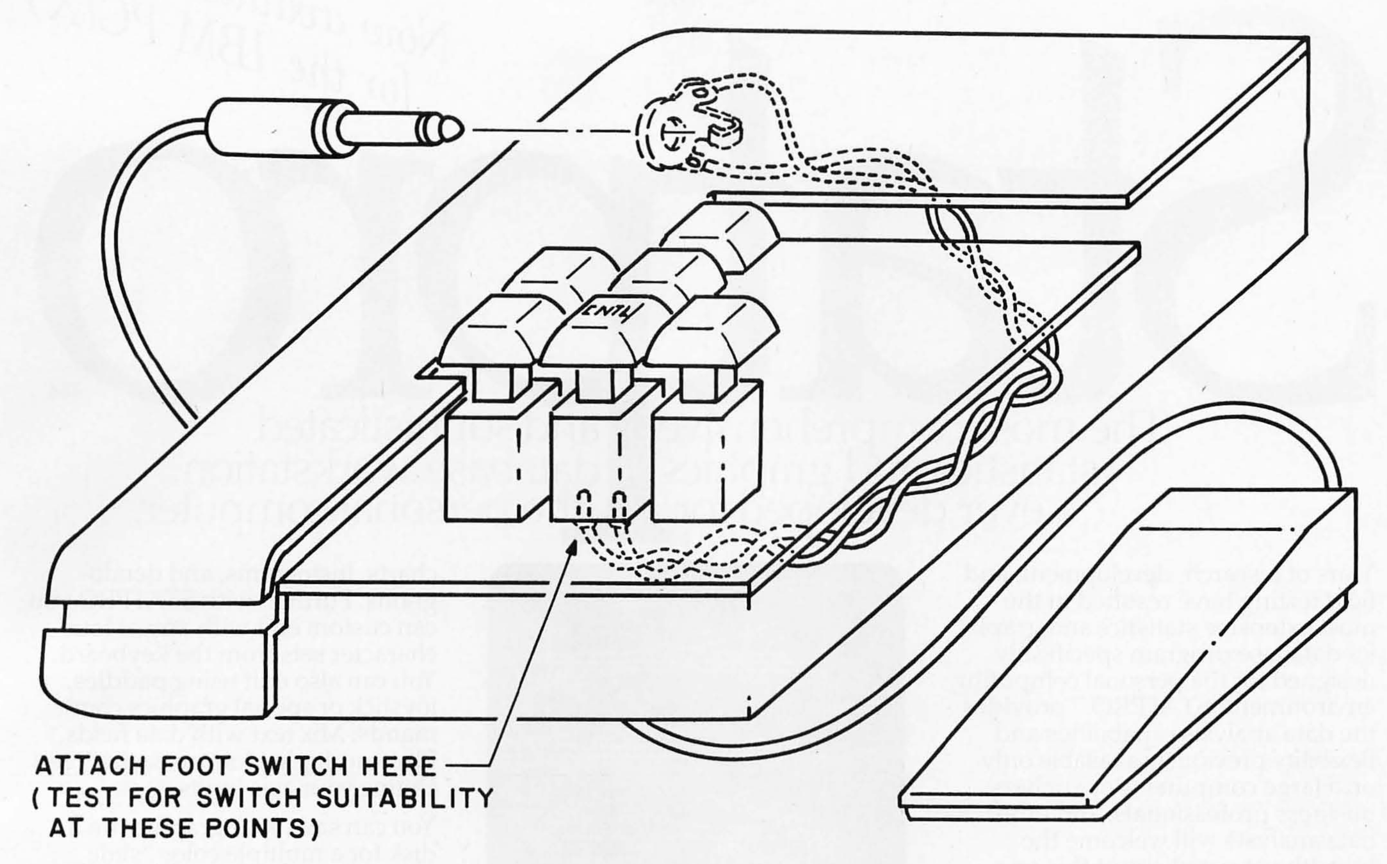


Figure 2: *A diagram of a foot switch Control key.*

closure. I think that the ability to rest your foot on the switch is a must for anyone engaged in long word-processing sessions.

Wire can be anywhere between 18 and 24 gauge and should be stranded to ensure flexibility when routing the cable underneath your workstation. Stranded wire also provides greater resistance to breakage due to flexing.

If you decide that you want to have the capability of plugging and unplugging your foot switch from the keyboard, choosing the right plug and jack is almost purely a matter of aesthetics. Voltage and current levels associated with keyboards generally are so low that they can be discounted in the selection criteria. Just choose the plug and jack combination that provides the easiest mechanical installation.

The Installation

Keyboards are usually nothing more than switches grouped in matrix fashion (see figure 1). Your installation goal is to provide yourself with a duplicate Control-key switch wired in parallel with the existing keyboard Control-key switch. This allows you to use either the normal keyboard Control key or the foot switch as the Control key. Adding "pedal power" to your system requires only that your keyboard be of the mechanical-contact type and not, for instance, the capacitance type. There are ways to add the foot-control feature to capacitance-type keyboards, but the solutions are system-dependent. You will find that most systems are of the mechanical type. Write me if you have a capacitance or other type; I'll try to help.

The easiest way to check whether your system or terminal is suitable for conversion is to turn off the power, open the keyboard enclosure, and find where the Control-key terminals are soldered into the keyboard printed-circuit board (see figure 2). Using an ohmmeter, connect the probes across the two contacts associated with the Control-key switch, press the Control key, and see if there is a meter deflection with each pressing of the key. If so, your keyboard is suitable.

The only thing that remains to be done is the soldering of a wire from each contact of the Control key to the jack contacts. If you decide not to use a plug and jack, wire directly from the keyboard Control-key switch contacts to the foot switch. Be careful not to apply too much heat to your keyboard because it is easy to damage the keyboard printed-circuit board. Mount the jack on the keyboard case and reassemble the keyboard enclosure if required. Wire up the foot switch to the plug and insert the plug in the jack.

Plug in your foot switch, invoke Wordstar or whatever word processor you are using, and get ready for a new adventure in word processing. Now, whenever you need a Control key, just press the foot switch and the appropriate key. If you are like me, you will never go back to hunting for that keyboard Control key again. I also can guarantee that the addition of this foot switch will generate considerable comment and speculation from the uninitiated.■

Dennis M. Pfister (POB 1248, San Luis Obispo, CA 93406) is MIS manager at TRW Inc. He holds a B.S. degree in mathematics/computer science and is interested in motion control, electronics, computers, and music.

Inside a Compiler

Notes on Optimization and Code Generation

A look at Pascal/MT+86 and Pascal-86 shows you how to evaluate these and other compilers

by Kaare Christian

As compilers for microcomputers proliferate, an understanding of how those programs work can prove valuable to high-level-language programmers. Examining compiled code, for example, can help you pinpoint subtle programming errors, and it opens the door to speed improvements in time-critical program sections. An examination of two compilers—Digital Research's Pascal/MT+86 and Intel's Pascal-86—illustrates how compiler optimization and code-generation schemes affect compiler performance, but first let's consider compilers in general.

Compilers are relatively new to microcomputers. Early microprocessors, such as the 6502, were programmed mostly in assembly language or BASIC. The advantage of assembly language is performance—assembly-language mavens have managed to make even rudimentary processors such as the 6502 perform impressive tasks. Of course, the disadvantage is that it is very difficult to write new assembly-language programs, and it's even more difficult to rewrite or reuse existing programs.

Programming in BASIC is the other extreme. BASIC is easy to learn and easy to use for simple tasks because it is interactive. However, interactive languages are very slow because each statement in the language must be evaluated and interpreted on the fly as the program runs.

Programs written in compiled languages are easier to understand and modify than those in assembly language.

More and more people are using compiled languages for programming microcomputers because such languages avoid the difficulties of assembly and interpretive languages. Numerous compilers are available for microcomputers. There are compiled versions of BASIC and Pascal for microcomputers as well as compilers for languages such as C, FORTRAN, COBOL, and PL/I, which originated on larger computers.

Compilers

First, let's note some of the strengths of compiled languages. Compiled languages are easier to learn and more universal than are assembly languages. These features are important because there are too few programmers today. Programmers should learn generally useful tools, such as compiled languages, rather than special-case tools, such as machine-dependent assembly languages. In addition, programs written in the better compiled languages are easier to understand and modify than are programs written in assembly language. These factors are important because many programs are maintained by a number of people over a long period of time.

Another compiler advantage is that programs written in compiled languages execute much faster than do those written in interpretive languages, and speed is one of the major factors that determine what problems

a computer can solve. Numerous problems cannot be solved effectively in interpretive BASIC because it is hundreds of times slower than are the better compiled languages (reference 2).

If compilers offer so many advantages over assemblers and interpreters, then why aren't compiled languages more common in the microcomputer world? Unfortunately, many of the early microprocessors, such as the 6502, are unsuitable for use with compiled languages. In particular, the limited stack and lack of 16-bit arithmetic on the 6502 make it hard to write a good compiler for that machine. Just five distinct high-level languages for the Apple II—Pascal, FORTH, BASIC, Sweet 16, and FORTRAN—are available, according to a BYTE article by Jim Gilbreath and Gary Gilbreath (reference 2). It is not known how many of these languages are compiled, but from the fact that these languages are between 10 and 200 times slower than 6502 assembly language, it is apparent that the 6502 is not the machine of choice for high-level languages.

On machines such as the Z80, it is possible but difficult to write compilers. A dozen high-level languages for the Z80 were cataloged in the Gilbreath article: Coral, FORTRAN, PL/I, C, BASIC, ZSPL, Pascal, PLMX, Ada, FORTH, APL, and COBOL. The fastest of these are just twice as slow as Z80 assembly language, and an astonishing 35 high-level-language implementations on the Z80 are within a factor of 10 of Z80 assembly-language speed. The newer microprocessors are much more promising. The 8086, the 68000, and the NSC16032 all offer features that make compilers relatively easy to write.

Compilers on the 8080 produce code that is, at best, about twice as slow as code written in assembly language. In articles by Jim and Gary Gilbreath, BYTE recently benchmarked a wide variety of systems and languages by comparing their performances in the Sieve of Eratosthenes, a method for finding prime numbers (see references 1 and 2). The advantage of the Sieve of Eratosthenes method over more obvious approaches is that the Sieve can find prime numbers without using multiplication or division. The results of the Gilbreath benchmarks indicated that the assembly-language version of the Sieve running on the Z80 was twice as fast as the fastest compiled language and about four to eight times as fast as the more typical compilers. The bottom line for compiled languages on the rudimentary microprocessors is that they are much easier to use than assembly language, but they produce code that is significantly slower than handwritten assembly code.

On machines that more efficiently support compiled languages, there is a much smaller performance penalty for using a compiled language instead of assembly language. But just how much of a penalty? Several methods exist for discovering just how much performance is sacrificed when you use a compiler rather than an assembler. One technique is the benchmark.

Compilers avoid the difficulties of assembly and interpretive languages.

Benchmarks

The Gilbreath benchmark measured the speed of a large assortment of high-level programming languages running on a variety of machines, from microcomputers to mainframes. The results of this and other benchmarks provide useful information for people who are evaluating compilers. Many of the more popular languages, such as Pascal, are available from several different companies, and the Gilbreath benchmark results provide a direct comparison of competing products.

Most benchmark authors are very careful to point out that the results of a single benchmark, or of benchmarks in general, should not be overstated. Numerous factors should be considered when choosing a programming language and implementation. Among them are the features of the language, the documentation for the language, and the availability of programmers already skilled in the language. Add to that the available tools for the language, the availability of the language for the target computer system, and any extensions to the language that might be useful in your application.

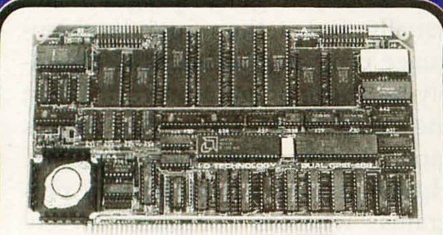
In the Gilbreath benchmark results, the enormous range of performance of the various languages and computers is striking. One might expect that a version of the Sieve written in assembly language for the IBM 3033 would be 400,000 *times* faster than a version written in BASIC for the PET. But why is an assembly-language version on the Z80 twice as fast as a CB80 version on the Z80, which in turn is twice as fast as an Aztec C version on the Z80, which in turn is twice as fast as Whitesmiths' Pascal on the Z80?

Benchmarks tell us which languages are fast and which are slow at performing the benchmark task. From a pragmatic point of view, a user cares only about performance, not about how that performance is attained. But from an inquisitive point of view, it's interesting to see what compilers do to achieve their level of performance.

Examining Code

Most compilers provide a feature that enables programmers to examine the code they are producing. Typically, these compilers enable you to create a listing file that contains the original source code interspersed with the assembly-language code that the compiler produced. On systems that lack an explicit code-examination feature, you can examine the code by using a program debugger or a separate disassembler program, but in that case even more sleuthing is necessary. If you plan to rely upon a compiler, it is certainly best to use one that shows you its code so that you can tune performance when necessary, verify correct operation, etc. Convenient access to generated code is one of the most im-

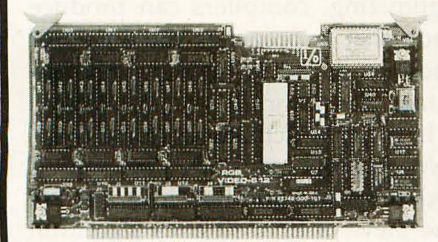
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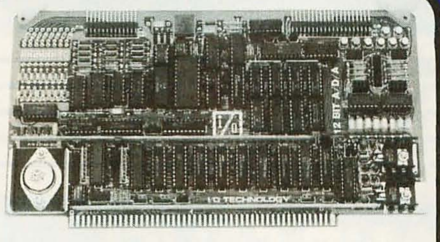
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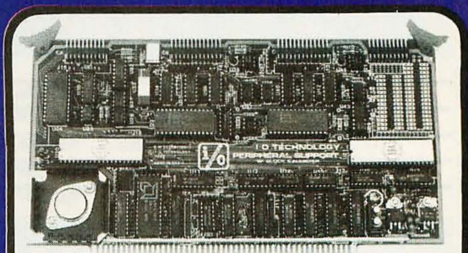
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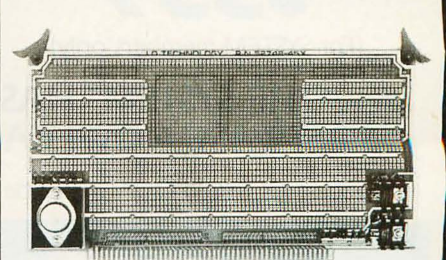
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portant features of any compiler.

Compilation usually consists of two separate parts: analysis (often called syntax analysis) and code generation. The analysis section deciphers (understands) your original program; the code-generation section actually creates the machine-language output. Syntax analysis is one of the better-understood techniques in computer science, whereas code generation remains a black art. Because each computer has a unique instruction set, it is necessary to rework (and rethink) the code-generation part of a compiler each time the compiler is transported from one machine to another. Why does one compiler produce faster code than another? Although there are no simple answers, two basic reasons emerge: (1) compilers use different schemata for code generation, and (2) compilers perform varying amounts of optimization on their code.

A compiler's schema is its basic philosophy of code generation. The schema dictates what code is generated for each feature in the high-level languages.

Assembly-language programs are usually faster than high-level-language programs because the assembly-language programmer can adjust the code to fit the circumstances more flexibly than can a compiler. Human coders can *understand* programs, whereas compilers merely translate programs. Experienced programmers usually can tell what's important in a program, which often enables them to apply shortcuts that improve performance at the expense of generality.

To improve their code, compilers usually perform optimizations. By optimizing, compilers can produce code that approaches the speed of code produced by an assembly-language programmer.

In order to actually examine these two aspects of code generation (schemas and optimization), I wrote the Sieve of Eratosthenes algorithm in "pure" Pascal. I chose Pascal because several Pascal compilers are available in the Rockefeller University laboratory, where I work, and because it is one of the most popular

Listing 1: *The Sieve of Eratosthenes in Pascal.*

```
program sieve (input,output);
(* the sieve in pascal *)

const size = 8190;

var flags : array[0..size] of boolean;
  i,prime,k : integer;
  count: integer;

begin
count := 0;
(* init flags array *)
for i := 0 to size do
  flags[i] := true;
(* look for primes *)
for i := 0 to size do
  if flags[i] then begin
    (* found one! *)
    prime := i + i + 3;
    k := i + prime;
    while k <= size do begin
      (* rule out multiples *)
      flags[k] := false;
      k := k + prime
    end;
    count := count + 1
    end;
end.
```

microcomputer languages.

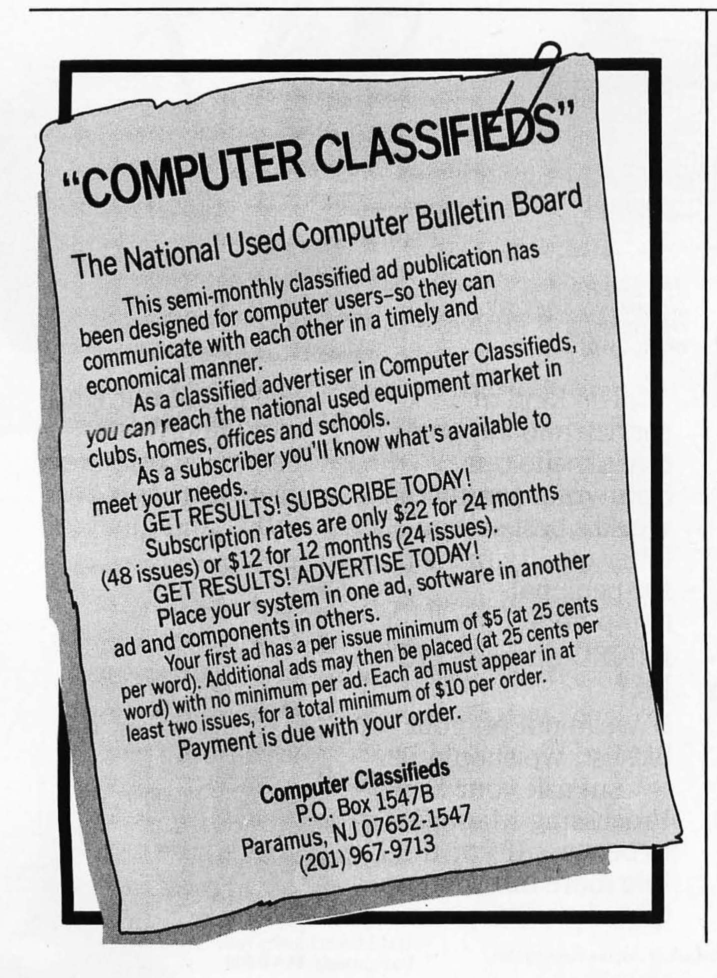
A Tale of Two Compilers

Listing 1 shows my version of the Sieve in Pascal. It is an almost direct copy from the Gilbreath benchmark. I compiled my version on two compilers for the Intel 8086 microprocessor. The first compiler is Digital Research's Pascal/MT+86 version 3.1 running under the CP/M-86 operating system, also from Digital Research. The second compiler is Intel's Pascal-86 version 2.0 running under the Intel iRMX/86 operating system. Both compilers accepted the listing 1 version of the Sieve without complaint, and both compilers produced working programs. I have used both compilers in the past and I have found that both are trustworthy products.

All of the measurements were performed on an Intel SBC 86/14 single-board computer running the iRMX operating system. The board is configured to run at 8 MHz. Where necessary, assembly-language code produced by Pascal/MT+86 was ported to the 86/14 and assembled using Intel's ASM86. Reference data for the 8086 microprocessor was taken from *The 8086 Family User's Manual* (reference 6).

All of the timings presented in this article were produced by running the code and measuring the time for a certain number of iterations. The times are slightly slower than "book" times for two reasons: (1) the 8086 I used was suffering wait states due to slow memory-access times, and (2) the repetition loop introduced some overhead. (Executing the code a large number of times made it possible to measure the time with a stopwatch rather than with a logic analyzer or scope.)

It would be impossible to detail the code for all the features of Pascal in a single article. Instead, I have chosen to focus on two examples of code generation: one that illustates the effect of optimizations and one that shows the different FOR loop schemata used by the two compilers. You should perform your own investigation if you are interested in



some other feature of code generation.

An Example of Optimizing

The primary responsibility of a compiler is to produce correct code. This doesn't mean that the program is correct, merely that the operations written in the high-level version of the program are correctly performed in the machine-language version produced by the compiler. The program may be wrong, but it isn't the compiler's fault.

Most compilers strive for more than correct codes; they want to produce fast code. Fast code usually requires optimizations. I envision optimizations as modifications to a compiler's basic code-generation schemata. For instance, the following 8086 assembly code would initialize the variable named TFLAG to the value 0:

```
MOV TFLAG,0
```

On the 8086 this instruction is 6 bytes long and takes 16 basic clock cycles to execute. This code could serve as a compiler's schema for initializing variables. How could we improve upon this schema? Suppose *that* the operation occurring just before the MOV TFLAG,0 operation left the value 0 in the accumulator. Given that the AX (accumulator) register already contains a 0, the following 8086 assembly-language instruction can initialize the variable named TFLAG:

```
MOV TFLAG,AX
```

Although this instruction doesn't look very different from MOV TFLAG,0, the improvement is dramatic. The 8086 MOV TFLAG,AX instruction is just 3 bytes long and takes only 10 basic clock cycles to execute, yielding nearly a 50 percent improvement. This second version could *not* serve as a basic schema for initializing variables because it relies upon the previous contents of the accumulator. However, if a compiler recognized those cases where the accumulator contained the required value, then it could perform this optimization.

Listing 2: *The 8086 assembly-language code generated by the Pascal/MT+86 and Pascal-86 compilers for the following two statements from the listing 1 program:*

prime :=i + i + 3;
k := i + prime

Pascal/MT+86 Code

```
   ;PRIME := I + I + 3
1  MOV  AX,I          ;Place the value of I into AX register
2  ADD  AX,I          ;Add the value of I to AX register
3  ADD  AX,3          ;Add 3 to the AX register
4  MOV  PRIME,AX      ;Store the AX register in PRIME
   ;K := I + PRIME
5  MOV  AX,I          ;Place the value of I into AX register
6  ADD  AX,PRIME      ;Add the value of Prime to AX register
7  MOV  K,AX          ;Store the AX register in K
```

Pascal-86 Code

```
   ;PRIME := I + I + 3
8  ADD  AX,AX         ;Add AX register to itself yielding I + I
9  ADD  AX,3          ;Add 3 to the AX register
10 MOV  PRIME,AX      ;Store the AX register in PRIME
   ;K := I + PRIME
11 ADD  AX,SI         ;Add AX register to SI register yielding I + PRIME
12 MOV  K,AX          ;Store the AX register in K
```

Pascal/MT+86		Pascal-86		
Statement Number	AX Register	Statement Number	AX Register	SI Register
1	—	8	I	I
2	I	9	I+I	I
3	I+I	10	PRIME	I
4	PRIME			
5	PRIME	11	PRIME	I
6	I	12	K	I
7	K			

Table 1: *Register contents during execution of the listing 2 code. Note that the value indicated in this table exists in the register at the* start *of the instruction cycle.*

I examined the assembly-language code produced by the Pascal/MT+86 and Pascal-86 compilers for the Sieve program in order to find a good example of optimizations. I chose the following example because it is relatively simple and because it clearly illustrates how optimization can improve performance.

Whenever a new prime is located, the listing 1 Sieve program computes two values, PRIME and K. Two Pascal statements compute PRIME and K:

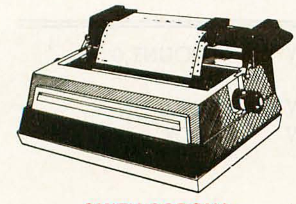
```
prime := i + i + 3;
k := i + prime;
```

The Pascal/MT+86 code and the Pascal-86 code produced by these two statements are shown in listing 2. The assembly-language code in all the figures in this article uses the mnemonics and assembly-language directives supported by the ASM86 assembly language. Note that listing 2 is an excerpt from listing 3, which shows the complete code generated by both compilers for the Sieve.

The Pascal/MT+86 code can be understood simply by reading through it and noting the sequence of operations. The Pascal-86 code is much harder to understand because it is heavily optimized. In order to

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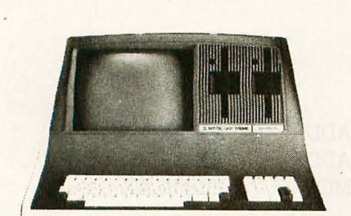


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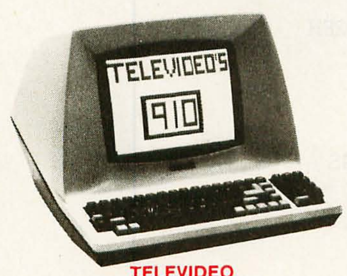
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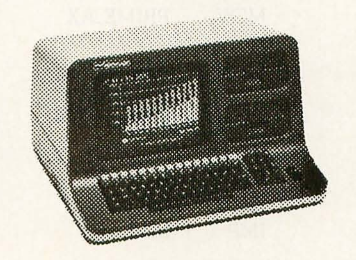
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Listing 3: *The complete code produced by two compilers for the listing 1 program.*

Pascal	Pascal/MT+86			Pascal-86		
count := 0;		MOV	COUNT,0		MOV	COUNT,0
for i := 0 to		MOV	I,OFFFFH		MOV	CX,0
size do		MOV	DS:WORD PTR 202CH,1FFFH	P5:	MOV	I,CX
	M4:	INC	I			
		DEC	DS:WORD PTR 202CH			
		JGE	M2			
		JMP	M3			
flags[i] := true;	M2:	NOP			MOV	SI,CX
		MOV	AX,OFFSET FLAGS		MOV	FLAGS[SI],1
		ADD	AX,I		INC	CX
		XCHG	AX,DI		CMP	CX,1FFEH
		MOV	BYTE PTR [DI],01		JLE	P5
		JMP	M4			
for i := 0 to	M3:	MOV	I,0FFFFH		MOV	AX,0
size do		MOV	DS:WORD PTR 202EH,1FFFH	P6:	MOV	I,AX
	M12:	INC	I			
		DEC	DS:WORD PTR 202EH			
		JGE	M5			
		JMP	M6			
if flags[i] then	M5:	NOP			MOV	SI,AX
begin		MOV	AX,OFFSET FLAGS		TEST	FLAGS[SI],1H
		ADD	AX,I		JE	P7
		XCHG	AX,DI			
		TEST	BYTE PTR [DI],01			
		JNZ	M7			
		JMP	M8			
prime :=	M7:	MOV	AX,I		ADD	AX,AX
i + i + 3;		ADD	AX,I		ADD	AX,3
		ADD	AX,3		MOV	PRIME,AX
		MOV	PRIME,AX			
k := i + prime;		MOV	AX,I		ADD	AX,SI
		ADD	AX,PRIME		MOV	K,AX
		MOV	K,AX			
while k <= size	M11:	CMP	K,1FFEH	P8:	CMP	K,1FFEH
do *begin*		JLE	M9		JNLE	P9
		JMP	M10			
flags[k] :=	M9:	NOP			MOV	SI,K
false;		MOV	AX,OFFSET FLAGS		MOV	FLAGS[SI],0
		ADD	AX,K			
		XCHG	AX,DI			
		MOV	BYTE PTR [DI],0			
k := k + prime		MOV	AX,K		MOV	AX,PRIME
		ADD	AX,PRIME		ADD	AX,SI
		MOV	K,AX		MOV	K,AX
end;		JMP	M11		JMP	P8
count :=	M10:	MOV	AX,COUNT	P9:	INC	COUNT
count + 1		INC	AX			
		MOV	COUNT,AX			
end;	M8:	JMP	M12	P7:	MOV	AX,I
					INC	I
					CMP	AX,1FFEH
					JLE	P6

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Compiler	Time (microseconds)	Size (bytes)
Pascal/MT+86	31	23
Pascal-86	18	13

Table 2: *Summary of results of the listing 2 code.*

Text continued from page 356:
understand the Pascal-86 code, examine table 1, which details the register usage. I deduced the first line in table 1 by backtracking through the code. Given that the accumulator contains the value of I, it makes perfect sense to compute I+I by adding the accumulator to itself. This step is an optimization because doubling the accumulator won't normally double I; this particular optimization can therefore take place only when the accumulator contains I. This optimization gives the Pascal-86 code a one-instruction advantage over Pascal/MT+86 code.

Similarly, the code for computing K was optimized in Pascal-86 by taking advantage of the fact that registers happened to contain all of the necessary values. As the Pascal-86 instruction 11 in listing 2 starts to execute, the SI register contains the value of PRIME. Pascal-86 simply adds the two registers together to form K and then stores the result in K, saving one instruction over the more obvious approach taken by Pascal/MT+86. The total code size and execution times for Pascal/MT+86 and Pascal-86 are shown in table 2.

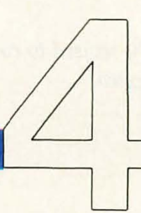
Could these examples be improved by an assembly-language programmer? A programmer might be able to produce a Sieve program that was faster overall than the Pascal-86 code, but it would certainly be impossible to improve on the code that Pascal-86 generated for the computations of K and PRIME. The Pascal/MT+86 computation of K could easily be improved. As Pascal/MT+86 starts to compute K, the value of PRIME is already in the AX register. All that is required is to add in the value of I and store the result in K as shown below:

```
;k := i + prime
ADD AX,I        ;AX already
                ;contains
                ;PRIME, just
                ;add in I
MOV K,AX        ;Store result in
                ;K
```

This code saves one instruction and would make the Pascal/MT+86 code more competitive with the Pascal-86 code.

The Pascal-86 code for computing K and PRIME is devious. It uses an approach that is not recommended for human programmers because the code is hard to understand and hard to modify. Pascal-86 uses results of many previous steps as a starting point for computing K and PRIME. However, I believe that devious (but correct) code generated by an automaton (the Pascal-86 compiler) is acceptable. Programmers strive to create readable programs because programs that can be easily read can be used and maintained by others. In this case, the goal is to create readable

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Listing 4: *The 8086 assembly code generated by the Pascal/MT+86 and Pascal-86 compilers for the following listing 1 FOR loop:*

```
for i := 0 to size do
  flags[i] := true;
```

The code has been reformatted to make it more legible, and it has been slightly revised to conform to Intel op-code standards. Both routines have been assembled and tested.

Pascal/MT+86

```
1         MOV   I,0FFFFH               ;Initialize I to -1
2         MOV   DS:WORD PTR 202CH,     ;Initialize anonymous
                1FFFH
                                       ;  loop counter to 8191
3   M4:   INC   I                      ;Increment I
4         DEC   DS:WORD PTR 202CH      ;Decrement anonymous loop counter
5         JGE   M2                     ;Jump to M2 if loop should continue
6         JMP   M3                     ;Jump out of loop
7   M2:   NOP                          ;Do nothing
8         MOV   AX,OFFSET FLAGS        ;Place base address of FLAGS
                                       ;  array into AX register
9         ADD   AX,I                   ;Add I to the base address
                                       ;  in AX register
10        XCHG  AX,DI                  ;Put address of an element of
                                       ;  FLAGS array into DI register
11        MOV   BYTE PTR [DI],01H      ;Put a 1 (true) into element
                                       ;  of FLAGS array
12        JMP   M4                     ;Jump back to loop increment
                                       ;  section
    M3:
```

Pascal-86

```
13        MOV   CX,0H                  ;Put a zero into CX register
14  P5:   MOV   DS:I,CX                ;Place value in CX register into I
15        MOV   SI,CX                  ;Copy CX register into
                                       ;  SI index register
16        MOV   DS:FLAGS[SI],1H        ;Put a 1 (true) into an
                                       ;  element of FLAGS array
17        INC   CX                     ;Increment CX register
18        CMP   CX,1FFEH               ;Compare value in CX register
                                       ;  with Terminal Value
19        JLE   P5                     ;Jump back to P5 if loop should continue
```

Coding Method	Time (milliseconds)	Size (bytes)
Pascal/MT+86	265	39
Pascal-86	155	21
Author's Assembly Loop	120	15
Author's Assembly String	17	13

Table 3: *Summary of the performance of four routines used to initialize the FLAGS array.*

and maintainable Pascal source code. The object code generated by the compiler doesn't need to be readable—it should be correct and efficient.

The FOR Loop Schemata

The Sieve benchmark program includes two FOR loops: one loop to initialize the array of flags that form the basis of the Eratosthenes method and one loop to actually search for primes. The FOR loop is obviously a very important part of Pascal and it also happens to be one of the areas where the two compilers in this study use very different strategies.

We will examine the initialization FOR loop because it is the simplest FOR loop in the Sieve. Another reason for studying the initialization FOR loop is more subtle—this particular loop can be dramatically optimized. Listing 4 shows the code for the initialization FOR loop produced by the two compilers.

The coding schema for a FOR loop can be separated into three logical sections: the initialization of the loop, the test-and-increment section, and the body of the loop. A glance at listing 4 reveals that Pascal/MT+86 and Pascal-86 use different FOR loop structures.

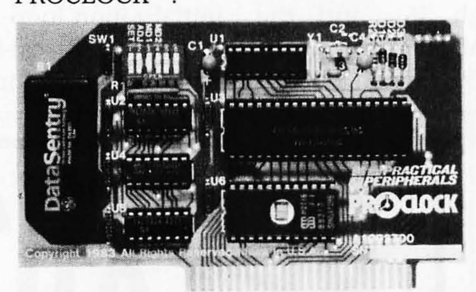
In Pascal/MT+86 the initialization section is at the top of the code (lines 1 and 2), the test-and-increment section is in the middle (lines 3 through 6), and the body of the loop is at the end of the code. The Pascal/MT+86 FOR loop is completely coded in twelve 8086 assembly-language statements containing 39 bytes of code. The execution time of the initialization FOR loop (8191 iterations) is 265 milliseconds (see table 3).

The Pascal/MT+86 FOR loop schema uses two loop counters, the visible loop counter named I and an anonymous loop counter created by the compiler. In the listing 4 code the anonymous loop counter is stored at location 202C hexadecimal and is referenced only twice, once in line 2 and once in line 4. The visible loop counter is incremented once each pass through the loop, whereas the anonymous loop counter is decremented each time through. The visible loop counter is initialized (in line 1) to be 1 less than the starting value, while the anonymous loop counter is initialized (in line 2) to be the number of passes through the loop plus 1. During each execution of the loop the anonymous loop counter actually determines whether the loop should continue. The visible loop counter (I) is just along for the ride and for use in the body of the loop.

Dual loop counters are the most striking feature of the Pascal/MT+86 FOR loop schema. What is to be gained from dual loop counters? Actually there is an advantage. Pascal is intended to be a very "safe" language. Pascal uses strong type check-

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ing, strict syntax, explicit declarations, etc., to safeguard against programmers' mistakes or laziness. One of the safeguards built into Pascal is the inviolability of the FOR loop. It is supposed to be impossible to prematurely exit from a FOR loop in Pascal. The initial conditions of the loop are evaluated once (when you enter the loop), and the loop counter itself should not be modified during the course of the loop. The dual loop counters of Pascal/MT+86 make it impossible for a programmer to prematurely exit the loop since the actual loop counter is inaccessible to a Pascal programmer. We will come back to this point shortly.

The next striking feature of the Pascal/MT+86 FOR loop schema is the presence of a pair of Jump statements on lines 5 and 6 of listing 4. One statement clearly would have been adequate. The conditional jump on line 5 is a "jump if result is greater than or equal" around the second jump. It would have been simpler and shorter to simply insert a "jump if result is less than" to M3. Another interesting feature is line 7, the "no-operation" line. Occasionally a compiler is forced to insert NOP codes in a program in order to fill reserved space. However, why should a NOP be the target of a Jump instruction? With miniscule effort the jump on line 5 could have used line 8 as the target instead of line 7.

One final comment must be made regarding the Pascal/MT+86 listing 4 code. The 8086 microprocessor has addressing modes specifically designed for accessing arrays of bytes or words. These addressing modes are ignored in the Pascal/MT+86 code shown in listing 4, and the address calculations are done explicitly in statements 8 through 11.

The FOR loop schema used by Pascal-86 is much leaner than the Pascal/MT+86 schema. The basic organization of the Pascal-86 FOR loop is different. In Pascal-86 the loop initialization is at the top (line 13), the body of the loop is in the middle (lines 14 through 16), and the test-and-increment portion is at the end. The Pascal-86 version doesn't use dual loop counters; it effectively uses the array addressing mode of the 8086 microprocessor, and it avoids back-to-back Jump statements.

The advantage of the Pascal-86 loop schema over the Pascal/MT+86 schema is obvious. The Pascal-86 code is 18 bytes shorter and executes 110 milliseconds faster. (The results are summarized in table 3.)

Could an assembly-language programmer produce a better initialization FOR loop than Pascal-86? Although I'm not a veteran 8086 assembly-language coder, I decided to attempt to improve on the Pascal-86 code. The easiest way to program in assembly language is to use a high-level language (Pascal, perhaps) as a crutch. Write the problem initially in the high-level language. Once the high-level language version is working, it is relatively easy to examine the compiler's code and then write an optimized version.

I was able to improve the Pascal-86 initialization loop very slightly (see listing 5). Pascal-86 used the CX register as the loop counter and the

Listing 5: *Two routines written by the author in 8086 assembly language. The first version is essentially an optimization of the Pascal-86 FOR loop; the second version uses 8086 string operations to achieve an enormous speed advantage. (Compilers cannot easily detect loops that could be recoded using string operations; programmers have a definite advantage in such situations.) Both routines were coded and tested using an Intel development system.*

8086 Assembly-Language Loop

```
         ;Initialize FLAGS array so that each element = 1
         ;Use SI to index FLAGS array and also as a loop counter

1        MOV   SI,0H            ;Put a zero into SI index register
2  L1:   MOV   FLAGS[SI],1H     ;Put a 1 (true) into an element
                                ;  of FLAGS array
3        INC   SI               ;Increment SI register
4        CMP   SI,1FFEH         ;Compare SI register with final value
5        JLE   L1               ;Jump back to L1 to continue
```

8086 Assembly-Language String Operation

```
       ;Initialize FLAGS array using string operations

6        PUSH  DS               ;Move contents of DS segment register
7        POP   ES               ;  into ES segment register
8        CLD                    ;Clear the direction flag
9        MOV   CX,1FFFH         ;Place iteration count into CX register
10       MOV   DI,OFFSET FLAGS  ;Place address of FLAGS array
                                ;  into DI index register
11       MOV   AL,01            ;Place a 1 in the AX byte register
12       REP   STOSB            ;Repeat the string operation
```

SI register as the array index. I combined these two functions in the SI register and saved one instruction. I also saved an instruction by keeping the loop count in the SI register; the Pascal-86 version copied the value to memory once per iteration. (I could have saved one more instruction by looping from 8190 down to 0 instead of looping from 0 up to 8190.)

This first assembly-language tweaking produced a modest improvement—the code shrank from 21 to 15 bytes and the time shrank from 155 to 120 milliseconds. The 35-millisecond improvement represented approximately a 20 percent increase in speed.

Can the initialization FOR loop be tuned even more? The 8086 microprocessor includes string instructions for performing operations on arrays or bytes or words. My second assembly-language coding effort produced a much faster version by using the 8086 string instructions. Notice that the string version in listing 5 doesn't even use an explicit loop; the actual iterations occur in statement 12 where the "store byte string" operation is repeated 8191 times. The assembly-language string version is 2 bytes shorter than the assembly-language loop version, and it is over six times faster.

Many observers have cautioned that tweaking code produces only modest improvements; dramatic improvements require changing the whole approach. In this example, tweaking produced a 20 percent improvement, whereas changing the whole approach by using the string instructions produced a sixfold improvement.

You should also note that the initialization code using the 8086 string instructions shown in listing 5 is not a general substitute for a FOR loop schema. The particularly simple FOR loop studied in this article happens to be expressible as a string operation—most FOR loops cannot.

Ramifications of the FOR Loop Schemata

The biggest difference between the FOR loop schema of Pascal/MT+86 and of Pascal-86 is MT+86's anonymous loop counter. We saw previously that the Pascal/MT+86 approach was used to make it impossible to exit a FOR loop prematurely by modifying the control variable. I decided to investigate how the Pascal-86 compiler protected the FOR loop because safe programming is so important to Pascal.

I coded the test shown in listing 6 in order to investigate the safety of the two Pascal compilers' FOR loops. The program attempts to short-circuit the loop by setting the loop counter variable I to 10 each time through the loop. The variable COUNT actually keeps track of how many times the loop operates. When I compiled the program in listing 6 using Pascal/MT+86, it compiled without complaint; when I executed the program I saw the message "10 iterations." When I compiled the program using Pascal-86, I received an error message informing me that it was not accept-

Listing 6: *A program that investigates premature exits from a FOR loop.*

```
program premature(input,output);
var i,count : integer;

begin
count := 0;
for i := 1 to 10 do begin
  count := count + 1;
  i := 10;
  end;
writeln(count,' iterations')
end.
```

Listing 7: *Pascal code containing a subroutine (named "shortcircuit") designed to circumvent Pascal-86 compilation safeguards.*

```
program premature(input,output);
var i,count : integer;

procedure shortcircuit;
begin
i := 10
end;

begin
count := 0;
for i := 1 to 10 do begin
  count := count + 1;
  shortcircuit
  end;
writeln(count,' iterations')
end.
```

able to change the value of I in mid-loop. Pascal-86 protects FOR loops during compilation by detecting assignments to the control variable, while Pascal/MT+86 protects FOR loops during execution by using dual loop counters.

Could either technique be fooled? After several false starts, I produced the program shown in listing 7. The coding techniques shown in the listing are definitely not recommended, although they appear to be legal in Pascal. Since I couldn't explicitly alter the loop index variable (I), I decided to use a subroutine to do the dirty work. The subroutine named Shortcircuit is designed to circumvent the compilation safeguards of Pascal-86. The program in listing 7 compiled without complaint using Pascal/MT+86 and Pascal-86. The loop executed 10 times in the MT+86 version and only once in the Pascal-86 version.

The Pascal-86 compiler does its best to protect the FOR loop at compile time, but the compiler can be fooled. The Pascal/MT+86 compiler protects its FOR loop during execution by using an inaccessible loop counter. I wasn't able to short-circuit the MT+86 method, but I was dismayed by the lack of warnings when I compiled the program in listing 6. It's up to you to decide which compiler's operation you prefer.

Conclusions

I hope that you don't decide to forgo the FOR loop in Pascal because of its overhead. In the great majority of FOR loops, calculations in the body of the loop dominate the execution time. Fine-tuning your programs for today's language implementations may allow marginal improvements, but your program wil be harder to understand and possibly harder to transport.

Similarly, I hope that all of you avoid the FOR loop short-circuit technique shown above. Clever programming can occasionally add a new feature to a language, such as the ability to prematurely exit a FOR loop. However, such programming is nonportable and hard to understand, and it may not even work when the next version of your compiler is released. Code generation enables us to understand why the Pascal/MT+86 loop is inviolable while the Pascal-86 loop is not, but if you program in Pascal, you should use FOR loops only when you really know in advance how many times you want to iterate.

For the most part you should strive for correct, clear programs. Speed is a secondary concern. People who write programs with a compiler's quirks in mind are trying to serve two masters. Programming is hard enough when you are serving a single master—correctness.

When is it appropriate to examine your compiler's code? Sometimes a program that appears to be correct is not working as you think it should. Examining the relevant code might reveal a bug in the compiler, although it is more likely to reveal a subtle error in your programming. Simply examining the code in a different form—assembly language—often reveals errors in your high-level-language programming.

Another reason to examine code is to speed up the time-critical section of a program. We've all heard that 10 percent of the code executes 90 percent of the time. If a small section of code must be rewritten by hand in assembly language, it is easiest if the code is programmed first in the high-level language and then optimized based upon the generated code. An added benefit of this technique is that the high-level version can serve as documentation, a much better form of explanation than the usual assembly-language documentation.

A final excuse for examining code is curiosity. Compilers perform a vital service, but we don't normally get to see the results. Poking around in the compiler's attic can be good clean fun. ■

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Inquiry No. Page No.

Inquiry No. Page No.

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Inquiry No. Page No.

Writing Device Drivers for MS-DOS 2.0

Using Tandon TM100-4 Drives

The increase in flexibility can be worth the added effort

by J. Eric Roskos

One of the many new features of MS-DOS 2.0 is its ability to allow you to write your own device drivers to be included in the operating system at start-up time. This feature lets you add new peripherals, such as disk drives, that are not supported by the standard software.

The IBM PC will support, without hardware modification, the Tandon TM100-4 disk drive. This drive looks exactly like a standard IBM double-sided drive except for the IBM insignia on the newer drive. In fact, Tandon is one of two IBM suppliers. The TM100-4, however, will hold twice as much data as the standard IBM double-sided disk. Unfortunately, MS-DOS 2.0, as configured for the IBM PC, cannot recognize this drive without some modification. Thus, MS-DOS 2.0 is a natural candidate for a user-written device driver. Though it is possible to patch DOS to make it work with this drive using existing device drivers, writing a new routine allows you to make optimal use of the TM100-4's features, such as the faster head-stepping rate that is possible with this drive.

In this article, I will describe the development of a device driver for the TM100-4, explain device drivers in general, and look in some detail at problems I encountered in developing this particular driver. These problems reflect some pitfalls that are characteristic of the IBM PC and DOS 2.0, so they are useful when writing other kinds of drivers as well.

Device Drivers

An MS-DOS 2.0 device driver consists of two separate procedures, called at separate times by DOS. These procedures are patterned closely after the device drivers in the Unix operating system produced by Bell Laboratories, although the DOS drivers' structure reflects an orientation toward assembly-language programming, whereas this part of Unix is written entirely in the C language.

The first of the two procedures that make up a device driver is the "strategy" procedure. It is called by DOS to request an operation from the device, such as a read or a write. The procedure stores the request and then returns to the caller.

The strategy procedure does *not* perform the requested operation; that is done by the second procedure, the "interrupt" procedure. It is important to understand the reason for this. In a well-designed operating system, I/O (input/output) operations should occur *asynchronously*. It may be possible to make the peripheral function more efficiently if you are allowed to make requests to it and it is then allowed to process them, without an unreasonably tight connection between the two events. For instance, it may help to let the device handler sort a set of requests in some strategic order that minimizes the amount of movement required by the disk heads. Likewise, it may help to allow the device driver to anticipate a future I/O request based on past ones and to prepare for it before the user requests it. Such advanced reasons are usually found only in multiuser (or multiprocess) operating systems and, in fact, DOS 2.0 does not make much use of them; but we can design better device drivers if we realize this underlying principle.

The interrupt procedure, the second of the two making up the device driver, is responsible for performing the operation requested by the strategy procedure. The interrupt procedure is called when the device is ready to handle another request. It looks for a request stored by the strategy procedure, and if it finds one, it executes the requested operation and signals DOS that it has done so by turning on a "DONE" indicator associated with the request.

In large operating systems, the interrupt procedure is called by the peripheral, which sends a hardware signal, or interrupt, to the microprocessor when it has finished a previously requested operation. This signal causes the processor to issue a subroutine call to the interrupt procedure, which starts the peripheral working on another request. In DOS 2.0, the interrupt procedure is instead always called by DOS immediately

after the strategy procedure is called, probably because this is an early version of the operating system that does not seem to use the fully asynchronous structure just described. In fact, the sample driver given in the DOS manual assumes that DOS will *always* call the interrupt procedure immediately after the strategy procedure, which would be incorrect in a truly asynchronous system. But even when asynchronous interrupts are used, the first time a device is used after it has been sitting idle, DOS will have to call the interrupt procedure to get things going, because an interrupt is generated only when a device first finishes an operation.

This means we don't have to worry about setting up the processor to produce interrupts (or about asking DOS to do it for us), but we can still program a device handler that has a structure much like those used in sophisticated operating systems. Thus, we can learn a lot about how device drivers work by constructing this relatively simple driver.

Disk Drivers

The kinds of requests that can be given to a device driver by DOS are listed in Chapter 14 of the DOS 2.0 manual. For a disk driver, the possible requests are as follows:

INIT—Initialize the disk hardware when the system is first started up. This procedure is always called exactly once, when DOS is started at power on or by pressing Ctrl/Alt/Del.
MEDIA CHECK—Check whether the user has changed disks since the last time the disk drive was used. For my device driver, I always tell DOS I "don't know" whether it was changed because for a floppy disk this is probably more efficient than reading the disk to see if it has been changed. An interesting alternative to this approach might be to tell DOS the disk hasn't changed if the disk motor is still on and tell it it has changed if the motor is off. The motor is turned off by the clock-handling routine in the ROM BIOS (the portion of the basic input/output system that is permanently stored in read-only memory) if the disk is not used for a few seconds; this provides a good guess as to whether the user might have changed the disk. If the user has changed the disk, the motor will be off (unless he is incredibly fast). Thus, if the motor is on, you can assume the user hasn't changed disks; in such a case, DOS would not reread the disk if the block being accessed was in memory, speeding up multiple accesses to the same block. The DOS manual doesn't tell exactly what the three alternatives (has changed, hasn't changed, don't know) do, so you are probably safer with the "don't know" alternative.
BUILD BPB—Tell DOS where in memory you have stored a table, called the BPB, describing the size of the directory and the number of blocks on the disk.
INPUT—Read from the disk into memory. DOS gives you the starting block number on the disk, the starting address in memory where you are to put the data, and how mar.y blocks you are supposed to read in.
OUTPUT—Write from memory to disk. DOS gives you the same information as for the INPUT function.
OUTPUT WITH VERIFY—Write from memory to disk, then verify that the data was written correctly. For our disk driver, we treat this request the same as a plain OUTPUT, although it would be fairly easy to add a function to check that the data was written correctly, since the ROM BIOS provides a VERIFY function.

The exact form in which a request is given to the driver is explained in Chapter 14 of the DOS manual. This data is called a "request header" and tells exactly what DOS wants the device driver to do. It always contains a "command code," a number identifying the functions to be performed; a "status word," in which we store information telling DOS whether we successfully performed the operation it asked for; and some other information that I won't go into here, telling the size of the request area in memory and the unit number when more than one device is to be handled by the same driver. The request header usually has other information following it in memory, such as the address and block numbers to be used for an INPUT or OUTPUT operation.

The two main things that a device driver for a disk must accomplish are the INPUT and OUTPUT operations. The other functions are fairly simple and may be based, with appropriate modifications, on the listing supplied in the DOS manual. I'll concentrate on the INPUT and OUTPUT operations in the remainder of this article.

Accessing the Disk

When DOS asks the driver to perform either an INPUT or OUTPUT function, it supplies three numbers that tell exactly what is to be done. The first is the "transfer address," consisting of two words. These words are the address in memory where the disk transfer is to take place. For an INPUT, this is where the data from the disk is to be stored as it is read from the disk. For an OUTPUT, this is where the data to be written onto the disk is found in memory.

To understand this, let's consider how a user's program would access the disk; for simplicity, let's say you want to read an integer from the disk in a BASIC program. You can't read just an integer, which is 2 bytes long, from the disk; the disk is read in blocks of 512-bytes. One of the functions of DOS (and the BASIC interpreter) is to figure out where on the disk the integer is stored; it will be in some 512-byte block of the disk, and this whole block has to be read into memory all at once, because that's how the disk works. So DOS sets aside an area in memory, called a *buffer*, into which the block is to be read. This area is entirely separate from your basic program and is invisible to you. It then asks the driver to read the block into the buffer, and after the driver has done so, it extracts the integer from the block and puts it into your BASIC variable.

It is the address of this buffer in memory that is the first of the numbers given to the driver with an INPUT or OUTPUT request. The driver does not have to set up the buffer or determine where data is on the disk; that is done by the higher-level parts of DOS. It only has to read one or

more 512-byte blocks from the disk *into memory* when requested. The second number given to the driver is the number of these 512-byte blocks that are to be read in. Often, only one block will be read at a time; but when a lot of data is to be transferred at once, such as when copying a file or saving the text from a word processor, many blocks may be read or written at the same time. The third number given to the driver is the "starting-block number" telling where on the disk this data is to be read or written. Because disks always work in terms of 512-byte blocks, the disk is divided up into a series of these consecutively numbered blocks; the block number is a "disk address" analogous to the memory address of a variable in memory, but the size of the object being addressed is much greater (512 bytes versus 1 byte).

```
AH = Function to be performed:
     0 = RESET the disk drive
     1 = get status information
     2 = READ from disk into memory
     3 = WRITE from memory to disk
     4 = VERIFY a write operation
     5 = FORMAT a track of the disk

AL = Number of sectors to transfer
CH = Track on disk to be used
CL = Sector within track to use
DH = Head on disk drive to use
DL = Disk drive to use

ES:BX = Address of buffer in memory
```

Table 1: *Before calling the ROM BIOS subroutine, you must load the appropriate information (shown above) into the BIOS registers.*

Operating the Hardware

I've just explained that when DOS asks the driver to perform an INPUT or OUTPUT, you'll be given information on where in memory and on disk the data is to be found or put. But you have to make the disk drive actually read or write the data. Fortunately, the program in the IBM PC's ROM (read-only memory), called the ROM BIOS, makes this easier. This program has subroutines for almost every hardware device available for the machine, including, fortunately, the TM100-4 disk, which is just another floppy-disk drive to the IBM PC. To use this subroutine, move information concerning what you want done into the 8088's registers and then call the subroutine via the 8088's INT instruction. However, there are two problems. First, the ROM BIOS doesn't know about DOS's block numbers; second, in any one call to the ROM BIOS subroutine, you can't transfer more than nine sectors at a time. (Depending on where the starting sector is on the disk, you may only be able to transfer less than nine.) The information you have to give DOS is listed in table 1.

Of the available functions, a DOS disk drive needs to use only functions 0, 2, and 3; these are the RESET, READ, and WRITE functions. Notice that locations on the disk are given in terms of the track, head, and sector. The track number identifies which of the concentric rings of data on the disk is to be used; the TM100-4 can store twice as much data as a standard double-sided drive because it has 80 tracks instead of 40. The head number on a double-sided disk drive such as the TM100-4 identifies the side of the disk you should use. And finally, the sector number tells which of the nine available sectors on a given track and side is to be used. (This sector number can be anything between 0 and 255; although Microsoft and I use numbers 1 through 9, any numbers can be used. This is how most copy-protection schemes work.)

To compute the track, head, and sector number from the DOS block number, we use the following formulas:

track = block / 18
TS = block mod 18
head = TS / 9
sector = TS − (head × 9) + 1

Because each track holds 18 blocks (9 blocks per side, 2 sides), the track number is the block number divided by 18 (using integer division). The value TS is the sector number within the track, a number between 0 and 17. If this number is less than 9, use head 0 and sector TS+1 (because sector numbers start at 1, not 0). If it's 9 or greater, subtract 9 from TS+1 and use head 1. In other words, the first 9 sectors are on head 0; the second 9 are on head 1. This is also how head, sector, and track numbers are calculated by the DOS disk drivers. For an introductory description of the ideas of head, sector, and track, see pages 1–10 of the DOS 2.0 manual; it provides more information on the basic concepts involved.

After you've translated the block number to the numbers required by the ROM BIOS, you have to break up requests for transfers bigger than can be handled at one time into consecutive requests to the ROM BIOS. The reason you have to do this is that the ROM BIOS doesn't know how DOS numbers sectors. It doesn't assume after it has transferred the last sector on track n that it can go to some other track and sector, say track $n+1$ sector 1. You have to tell it explicitly. So whenever the track or side (head) numbers change, you have to give the ROM BIOS another request.

Although this is somewhat complicated, if you sit down with pencil and paper you can probably write out a simple procedure, in the programming language of your choice, to solve the problems just described. This is not too difficult and is a good practice whenever you are programming a complicated procedure in assembly language. Unfortunately, there are some interesting and frustrating aspects of this problem that aren't documented in any manual—and this made my project much harder.

Unexpected Problems

When I wrote the original device driver, I used the example in the DOS manual as a guide. Within a reasonable amount of time, I had what should have been a working driver. But it wasn't that simple.

First, I had put some calls to DOS into my driver to display information so I could trace the activity of the driver for debugging. But the driver didn't work at all. It hung the system.

I tried using the debugger supplied with DOS. I traced the execution of the driver, using breakpoints at appropriate places. Strangely, the requests to the driver seemed to be get-

ting destroyed; and more strangely, no matter where I put the breakpoint, this would always happen sometime *after* the first breakpoint was hit. Finally, by more tracing, I discovered the first difficulty with writing device drivers for DOS 2.0: you can't use the debugger because the debugger uses DOS's I/O routines rather than having its own, as is desirable in a good debugger (a debugger should generally be as independent of anything else in the system as possible); and DOS's I/O routines are not "reentrant," meaning you can't call them from within a previous call on the I/O routines, or the former's data will be destroyed.

This was a disappointing setback. You can't use the debugger to debug the operating system because the debugger tampers with the data you're trying to examine. It's hard to understand why Microsoft designed it this way. It would be helpful if someone would develop a debugger independent of anything (except perhaps the ROM BIOS) to plug into the extra socket on the 5150 central processor (there's not a free socket on the 5160, so it wouldn't work there).

The second problem I had concerned the DOS I/O routines. They aren't reentrant. This is mostly because DOS seems to have been written in assembly language. Many of the idiosyncrasies of DOS could have been avoided if, when making a Unix-like single-user operating system, they had also followed the lead of Unix and written it in C, which uses a stack for local variables, thus tending to minimize problems such as those that occurred with the debugger and I/O routines.

After filling out one of the complaint forms in the back of the DOS manual to send to Microsoft, I proceeded to write my own routines to use the ROM BIOS to display debugging information on the screen. They are illustrated in listing 1. After replacing the original calls to DOS with calls on my new routines, I tested it again. A third problem emerged. No matter what I did, DOS would give the message *Sector size too large in file Tm4.com*. This message

Listing 1: *The ROM BIOS debugging routines.*

```
;
; debugging macros
;

;
; prtreg - print contents of register rg in hex, followed by message
;         string in msg, e.g.,     prtreg  ax,"=ax register"
;

prtreg  macro   rg,msg
        push    ax
        mov     ax,rg
        call    prtax
        wto     msg
        pop     ax
        endm

;
; wto - write mesg to display.  E.g.,     wto "I/O Error"
;

wto     macro   mesg
        local   msgstr,around

        ifdef   debug
        push    ax
        push    bx
        push    si
        mov     si,offset msgstr
        call    putc
        pop     si
        pop     bx
        pop     ax
        jmp     around

msgstr:
        db      mesg
        db      0DH,0AH,'$'

around:
        endif
        endm

;
; Local Procedures for debugging macros
;

;
; putc - equivalent of DOS function 9
;

putc            proc    near
                mov     bl,7
                mov     bh,0
putc1:
                mov     al,[si]
                cmp     al,'$'
                je      putc2
                mov     ah,14
                int     10H
                inc     si
                jmp     putc1

putc2:
                ret
putc            endp

;
; prtnum - print low-order 4 bits of al register in hex
;

prtnum          proc    near
                push    ds
                push    cs
                pop     ds
                push    bx
                mov     bx,offset xltab
                xlatb
                mov     ah,14
                mov     bh,0
                int     10h
                pop     bx
```

Listing 1 continued on page 374

Listing 1 continued:

```
                .pop    ds
                ret
xltab           db      '0123456789ABCDEF'
prtnum          endp

;
; prtax - print ax register's contents in hex
;

prtax           proc    near
                push    cx
                push    ax
                mov     al,ah
                mov     cl,4
                shr     al,cl
                call    prtnum
                pop     ax
                push    ax
                mov     al,ah
                and     al,0Fh
                call    prtnum
                pop     ax
                push    ax
                mov     cl,4
                shr     al,cl
                call    prtnum
                pop     ax
                push    ax
                and     al,0Fh
                call    prtnum
                pop     ax
                pop     cx
                ret
prtax           endp
```

Listing 2: *The device driver local stack routine.*

```
;
; Code used to set up a private stack for the device driver
;

; *** The following is in the code segment for the driver: because
; *** the code, stack, and data segments are set up to all start at
; *** the same address.

;
; Private stack - because DOS doesn't provide enough
;   room for us to do our debugging I/O
;
                db      102 dup ("TM4 Stack ") ; 1020 bytes stack area
stkbot          equ     $
                dw      ?       ; a little extra space just to be safe
                dw      ?

;
; Stack pointer save area
;
spsav           dw      ?       ; DOS's stack pointer is saved here
sssav           dw      ?       ; DOS's stack segment is saved here


;
; entry to / exit from device strategy: example of stack switching
;
dev_strategy:
                ; switch to private stack

                mov     spsav,sp        ; save DOS's stack pointer
                mov     sssav,ss        ; and its stack segment
                mov     ax,cs           ; stack is in the code segment, so we
                mov     ss,ax           ; set stack segment = code segment
                mov     sp,offset stkbot ; and point stack pointer to bottom
                                        ; of the stack
;
; *** Code for strategy routine goes here
;

                ; switch back to DOS's stack

                mov     ss,sssav        ; restore DOS's stack seg we saved
                mov     sp,spsav        ; likewise its stack pointer
                ret                     ; and return to DOS, who called us.
```

meant that my driver was telling DOS that the disk's sector size was something other than the intended 512 bytes. After careful examination, I found that this was false—the sector size was correct. At this point, only guessing and intuition led to a solution. I guessed that what was happening was that the system stack, a small stack local to DOS that is used in place of the user's stack whenever a DOS function is called, was overflowing and destroying some of DOS's data. This seemed possible because my debugging I/O routines saved all the system's registers, using a lot of space on the stack, and called ROM BIOS procedures, using even more. So I resorted to the unorthodox method of having the device driver set up and use its own local stack (this method remains in the finished driver). This eliminated the error message, although I have no concrete evidence that this was the cause of the error. This is not a satisfactory solution, because it means the driver takes up more space than it should and the method used to switch stacks is complicated, much like a context-switching operation used in a multitasking operating system to switch between several programs running at the same time. But this solution does assure that the driver will have a known amount of stack space, and it eliminates the error message. The method used to switch to a local stack is illustrated in listing 2.

Hardware Limitations

Following this improvement and the addition of some macros to print the contents of the registers on the screen, debugging proceeded about as expected for a while. The driver seemed to be working at last. But then, while copying a large file, an I/O error occurred. The error code returned by the BIOS was code "09"; according to the ROM BIOS listing in the Technical Reference manual, this means "attempt to DMA across 64K boundary." This was the first reference I had seen to what turned out to be a difficult, and largely undocumented, hardware restriction on the IBM PC. When doing I/O to the disk

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using the conventional hardware approaches (those used by the ROM BIOS), you can't read or write a block that lies across a 64K-byte boundary. This has nothing to do with the segmentation registers, which are the usual cause of 64K-byte restrictions. Instead, it has to do with the way the circuit is built (as seen on sheet 4 of the 64/256K-byte System Board diagrams). Although it isn't documented clearly, memory on the IBM PC is partitioned into 64K-byte blocks for purposes of DMA (direct-memory access) I/O. Chip U19 on the central processor board is a "DMA page register" that must be given the upper 4 bits of the address of the buffer to be read or written before the I/O operation starts. This will determine the upper 4 bits of the address in memory at which the I/O will occur. Since this can't be changed while the I/O is going on, you can't do I/O to a buffer lying on a 64K-byte boundary. For instance, you can't have a buffer that starts at hexadecimal address 0FF00 and goes through address 10100, because that lies on a page boundary; note that the upper 4 bits of the starting and ending address differ.

This wouldn't be so bad except that DOS regularly tries to do I/O operations using buffers that lie on page boundaries. This happens, for instance, when the COPY command is used to copy a large file if your machine has more than 64K bytes of RAM (random-access read/write memory).

Again, it's hard to understand why this was done. Certainly the new I/O functions provided in DOS 2.0 that use a pool of buffers maintained by the operating system shouldn't have to do this, and probably don't; the buffer pool almost certainly can be allocated to avoid these 64K-byte boundaries. It would also have seemed reasonable for functions such as COPY to check and not attempt such I/O. It's true that user programs would have to be restricted not to attempt such I/O either, if they were using the "raw" I/O functions provided by DOS. Perhaps this was an attempt to allow DOS to smooth over irregularities in the hardware, as a good operating system should. As such, it was not a bad design decision, but it does make writing device drivers more difficult, especially since documentation of this restriction is so sparse. The only case in which such a restriction is necessary, raw I/O by the user, is not desirable in any operating system because it minimizes protection by the system against the user accidentally destroying valuable data in memory.

I solved this problem in my driver by checking whether a requested I/O operation crossed a 64K-byte boundary. If it did, I transferred up to the block that crosses the boundary. Then, I copied the offending block to a local buffer within the driver and transferred it; then I transferred all the data following the boundary-violating block. This requires three transfers where one would have sufficed, but it solves the problem. This may not be the best method—there may be some hardware trick to solve the problem, but if there is, it's not documented. The method I used



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complicates the code (and, in fact, my solution does an unnecessary copy in the case of an INPUT operation because of the way the program is structured), but it works, and there is no visible degradation in performance.

The Finished Program

The finished device driver is a fully functioning driver for a TM100-4 disk configured as device 1 (the drive normally called B: by DOS). It assumes that the device 0 (or A:) drive is a standard IBM disk drive compatible with either the TM100-1 (single-sided) or TM100-2 (double-sided) disk drive. This is probably the best approach to use, unless you have an expansion chassis supporting more than two disk drives, because IBM and the other software suppliers all distribute their programs on the standard 40-track disks, and these do not appear to be readable on the TM100-4 with IBM's disk controller.

A major feature of this disk driver is that it changes the head-stepping rates for both the standard TM100-2 drive and the TM100-4 to rates that seem to work much better. Specifically, the TM100-2 is operated at 4 ms (milliseconds) per step and the TM100-4 is operated at 2 ms per step. This is slightly faster than the specified optimal stepping rate for the drives (the optimal rates are not possible because the fast clock rate on the IBM PC causes the controller's stepping rate to be settable only in increments of 2 ms, and the optimal rates are 5 and 3 ms, respectively). Using these rates causes the heads to move smoothly and quietly, eliminating the loud and irritating buzzing noise usually produced by the drives. If you find that your drives will not work at these rates, you can change them to slower values, but it is important not to operate the TM100-4 at a 4-ms step rate, because it is claimed by at least one vendor (Network Consulting, Inc.; see the warning on page 3 of chapter CONFIG.IBM(Utl) in the UCSD p-System programmer's guide dated 16 March 1983) that a "serious vibration problem" exists that can damage the drive if a 4-ms stepping rate is used. I have used my disk drives at the rates set by this driver for the past eight months with no adverse effects or increased I/O error rate; in fact, it would seem that the reduced vibration levels produced by operating the heads close to their specified optimal rates would reduce wear on the head supports and other parts in the drive.

Future Enhancements

One advantage of having your own disk driver is that you can devise ways to further increase the storage capacity of your drives. One of the easiest ways to do this is to go to 10 sectors/track instead of 9. This feature is currently available under some implementations of the UCSD p-System, where it appears successful. However, it requires changing various timing parameters provided to the disk controller, and thus it is not as easy as going from 8 to 9 sectors per track.

Retrospective

In looking back on this project, several things are apparent. The first and most important is that, if I were writing the driver over, I would do it in C. I used assembly language primarily because I did not have a C compiler. I have subsequently purchased a C compiler that would be well suited for this application; I have used it to write several stand-alone device-handling programs. I would guess that it would have taken me a third of the time it took me to implement the program in assembly language if I had used C, because the majority of bugs, other than the problems described in this article, were related to register and addressing complications and structural flaws in the code that would have been avoided or easily detected if a block-structured language had been used.

I favor C for this project because it is not strongly typed but has powerful control structures, unlike either Pascal, which is strongly typed and has weaker control structures, or systems-programming languages such as BLISS, which essentially has no typing at all and relatively weak control structures.

It is also apparent that DOS 2.0

would have benefited from the use of C. This version of DOS is obviously patterned after Unix; even the names of the system calls are the same as in Unix (more exactly, it is a subset of Xenix, which was patterned after Unix). Unix began as an assembly-language system but was quickly revised to be written in C. Some of the benefits of this approach would have been a more uniform calling sequence for the DOS system calls (presently they tend to be irregular) and a much greater likelihood that the operating system's routines would be reentrant, because C and similar programming languages store most variables on the stack. If all "static" variables are properly used, implementation of multitasking is much simpler and does not involve the previously described problems.

Finally, debugging this device driver was enormously difficult because of the absence of adequate debugging facilities. A large software house probably would have an Intel Development System or a similar facility to provide hardware tracing for debugging, but the average user does not have such equipment. Anyone attempting to implement a device driver for this system would do well to first obtain or write a good stand-alone debugger. Unless you have considerable patience, experience, and intuition, locating bugs in such a program is difficult.

Conclusions

It is feasible to write device drivers for MS-DOS 2.0, although debugging can be difficult. This is a good feature of the operating system, as is its structure. Some problems, as explained previously, exist; with luck these can be ironed out.

A project such as this can give you a better feel for what goes on within a given operating system than does user-level programming. At present, MS-DOS is rather complicated. The original system, developed outside Microsoft, was written quickly and lacked many necessary features. Considerably more expertise (as well as an understanding of Unix) was involved in developing version 2.

Yet MS-DOS still seems to be subject to two opposing forces. One steers it toward a fairly good structure, perhaps because of the upward-compatibility with Xenix that it is supposed to have. The opposing force, fostered largely by the continued use of assembly-language coding, is steering it towards the old-fashioned disarray and patchwork familiar to anyone who has done systems programming for one of the older operating systems on mainframe machines. Hopefully, with new features such as the ones discussed in this article, the former will prevail in the end.■

J. Eric Roskos (Box 120562, Nashville, TN 37212) is a graduate student at Vanderbilt University whose dissertation is on a new architecture for multiprocessor shared-memory systems and related theories of communication and synchronization.

For more information on the source code used to construct this device driver, please contact the author.



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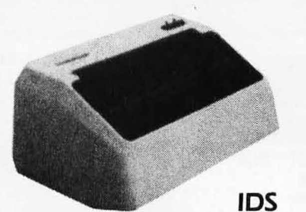
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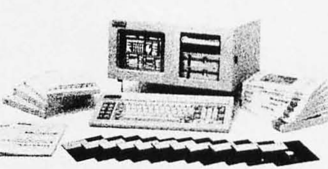
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Deciphering Word Games

Two BASIC programs that will help you solve cryptograms and anagrams

by Mark C. Worley

Puzzles fascinate me. As a youngster, I loved encrypted codes, secret languages, decoder rings, and similar puzzles. I still enjoy decoding word puzzles; all the more so when they're as close at hand as cryptograms or anagrams in the local newspaper.

The cryptograms in newspapers are short messages, often only a few sentences long, in which each letter of the original text has been replaced by some other letter of the alphabet. Usually the substitutions are random choices without a pattern. For example, the latter *a* may replace all the *t*s, while *b* replaces all the *o*s. One particular letter is never used for more than one coded letter. Sometimes a few letters will not be encoded at all; they remain the same in the encoded message as in the decoded plain text.

Anagrams are words whose letters have been rearranged into a meaningless jumble. The trick is to put them back into their proper order to spell a word. For example, SIBAC is an anagram for BASIC. The longer a word, the more possible combinations it has. For instance, a three-letter word has six possible combinations: $1 \times 2 \times 3 = 6$. A four-letter word has 24 possible combinations: $1 \times 2 \times 3 \times 4 = 24$. A five-letter word has 120 combinations, six letters have 720 combinations, and so on. You can spend a lot of time trying to find the hidden word in a six-letter anagram unless, of course, you are inherently intuitive or prone to logical analysis. (Some people just go on to the comics page.)

Cryptograms are a particular challenge to decode because of the continuing search for the correct letter substitutions, or keys, to the cryptogram. Prior to computers, this search would consume a lot of paper, pencil lead, erasers, and patience as each new key was tried out in the text. With computers, the monitor provides a constantly fresh worksheet and the keyboard becomes a pencil that never dulls with an eraser that always wipes cleanly. Perhaps you will be interested by the following programs written in Microsoft Extended BASIC that can help you enjoy solving word games.

To Solve a Cryptogram

Crypto.bas is a program ideally suited for solving the short- to medium-length crytograms frequently found in the corners of newspaper pages. Using a 24-line by 80-character display monitor, Crypto.bas displays almost 400 workspace characters. This means that five lines of code and workspace, 79 characters long, can be displayed. Those of you with smaller screens will have less available workspace, but the program can be modified for your screen size by changing the 79 in line 50 to 1 less than your screen width. For instance, if your screen is limited to 40 characters, then change the 79 to a 39.

To decode a cryptogram, load and run Crypto.bas (see listing 1). The screen will clear and the command

TYPE THE CRYPTOGRAM:

will appear on the screen, along with an on-screen ruler showing 79 dashes. The input command LINE INPUT allows punctuation to be included in the string. The ruler is printed to help eliminate entering an 80-character line, which usually results in an automatic carriage return and line feed (CR LF) on the screen. These unexpected CR LFs use up extra space in the display and generally make the display unmanageable. If the cryptogram occupies more than one displayable line, type what you can, then enter new lines by hitting the Enter or Return keys. When you have finished entering the entire cryptogram, hit Enter or Return on a blank line.

Line 80 in listing 1 checks for a 0-length line. When a 0-length line is encountered, variable A is set to equal the number of lines entered, then a subroutine counts the frequency of each character. The MID$ and ASC commands count the characters quickly.

The next subroutine, beginning on line 480, starts with ASCII character 65 (capital *a*) and continues through

Listing 1: *Crypto.bas is a program in BASIC used to solve and create your own cryptograms.*

```
10 REM CRYPTO.BAS PGM TO EASILY WORK CRYPTOGRAMS  12/31/82
20 PRINT CHR$(12)                              'CLEAR THE SCREEN (CLS)
30 DIM GN(95),AMT(95)
40 PRINT"TYPE THE CRYPTOGRAM:                    Terminate with a blank line <CR>"
50 PRINT STRING$(79,95)
60 LINE INPUT Z$(A)                            'LINE INPUT ALLOWS PUCTUATIONS
70 LET LL(A)=LEN(Z$(A))                        'LL(A)=LINE LENGTH
80 IF LL(A)<>0 THEN A=A+1:GOTO 50              'BLANK LINE TERMINATES INPUT
90 A=A-1                                       'A=# OF LINES IN CRYPTOGRAM
100 GOSUB 390                                  'COUNT LETTER FREQUENCY
110 FOR X=0 TO A:X$(X)=Z$(X):NEXT X            'MAKES CRYPTO & WORKSPACE EQUAL
120 PRINT CHR$(12)                             'CLEAR SCREEN (CLS)
130 FOR Y=0 TO A                               'A=# OF LINES IN CRYPTOGRAM
140  PRINT Z$(Y):PRINT X$(Y)                   'PRINT CRYPTO & WORKSPACE
150   IF PF=1 THEN LPRINT Z$(Y):LPRINT X$(Y)
160  PRINT:IF PF=1 THEN LPRINT                 'AND A SPACE BEFORE NEXT LINES
170 NEXT Y                                     'PRINT NEXT CRYPTO/WORKSPACE LINES
180 PF=0                                       'CLEAR PRINT FLAG
190 '    ***  PRINT THE FIVE MOST FREQUENTLY USED CHARACTERS  ***
200 PRINT "CRYPTOGRAM: ";
210 FOR Y=1 TO 5
220  IF G(Y)<>0 THEN PRINT CHR$(GN(Y));"   ";
230 NEXT Y
240 PRINT "            TEXT LENGTH:";TEXT
250 PRINT "PLAIN TEXT: E   T   L   A   N"
260 PRINT:INPUT"ENTER THE LETTER TO BE CHANGED (or QUIT or PRINT) ";A$
270 IF A$="PRINT" THEN PF=1:GOTO 120                   'PF=PRINT FLAG
280 IF A$="QUIT" THEN END
290 INPUT"ENTER THE LETTER IT IS TO BE CHANGED TO";B$
300 '    ***  SEARCH FOR A$ IN Z$, THEN REPLACE IT IN X$ WITH B$  ***
310 '    ***  Z$ IS THE CRYPTOGRAM, X$ IS THE WORKSPACE            ***
320 FOR Y=0 TO A                       'A=# OF LINES OF TEXT
330  FOR I=1 TO LL(Y)                  'LL(Y)=LENGTH OF THAT LINE
340   IF MID$(Z$(Y),I,1)=A$ THEN MID$(X$(Y),I,1)=B$
350  NEXT I
360 NEXT Y
370 GOTO 120                           'PRINT CRYPTO & WORKSPACE W/CHANGES
380 '    ***       SUB-ROUTINE TO COUNT FREQUENCY OF EACH LETTER    ***
390 PRINT CHR$(12)STRING$(12,10) TAB(25)"COUNTING LETTERS"
400 FOR Y=0 TO A                       'A=# OF LINES OF TEXT
410  FOR X=1 TO LL(Y)                  'LL(Y)=LENGTH OF THAT LINE
420   Q$=MID$(Z$(Y),X,1):Q=ASC(Q$):AMT(Q)=AMT(Q)+1
430  NEXT X
440 NEXT Y
450 FOR X=0 TO A:TEXT=TEXT+LEN(Z$(X)):NEXT X    'TOTAL-UP TEXT LENGTH,
460 TEXT=TEXT-AMT(32)                           '& SUBTRACT SPACES FROM COUNT
470 '    ***      SELECT THE FIVE MOST FREQUENT LETTERS     ***
480 FOR Y=1 TO 5
490  FOR X=65 TO 90
500   IF AMT(X)>=G(Y) THEN G(Y)=AMT(X):GN(Y)=X   'FIND HIGHEST COUNT,
510  NEXT X                            '& STORE IT AS GN(Y)
520   AMT(GN(Y))=0                     'IGNORE THIS ONE NEXT TIME AROUND &
530 NEXT Y                             'LOOK FOR NEXT MOST FREQUENT LETTER.
540 RETURN
```

ASCII character 90 (capital *z*), searching for the largest value of AMT(X). AMT(X) is the variable that contains the frequency of occurrence of the letter whose decimal ASCII value is the X in AMT(X). Line 500 searches and compares each value of AMT(X) to find the highest value (or last-found highest value) if more than one character has an equal number of occurrences in the text. To ease decoding and the character-frequency count, you should enter the anagram in capital letters. The program can be modified to include in the character-frequency count coded messages that use numbers and other printable characters for letter substitutions.

After the five most frequent characters are found, the subroutine returns to line 110 where the cryptogram and workspace lines are printed. A line of the encoded text is printed, then a workspace line below that, followed by a blank line. This continues until the entire message is displayed. Below the text, the five most frequently used letters in the English language—*e, t, o, a, n*—are shown. Immediately below those letters the five most commonly used letters in the message are displayed. This provides as easy way for you to choose the first few letters for possible substitution into the encoded text. Also shown is a count of the total number of characters in the text, which is helpful to know. (There is some argument about what the most commonly used letters really are. According to various sources, they include the following combinations: *etlan, ethsi, etaoi,* or *etona*. The most commonly used character is actually not *e*, but the space between words. The frequency of spaces is important to recognize in many encoded texts and in text-compression storage methods.)

After the code is entered and displayed, you are prompted to begin substituting letters. Choose a letter in the coded text to be changed and enter it. Then choose a letter that should substitute for that letter and enter that. The program will now search for every occurrence of the first letter *in the coded text* and substitute the corresponding letter *in the workspace* with the second letter. The alternating lines of coded text and workspace will be reprinted on the screen with the coded text remaining unchanged and the workspace showing the substitutions. Now, a ready comparison can be made between the two versions to see if the substitution choice was a good one, and to see which is the best letter to try next. If the choice was a bad one, you can change the letters in the workspace back to the original or to some other letter. The top line of each pair of lines (the original cryptogram) always remains unchanged. Only the bottom line of the pair (the workspace) changes.

The program won't save the cryptogram on disk. However, if you've decoded it or are interrupted and want to save your work, enter PRINT in answer to the prompt from program line 260. PRINT will save the cryptogram and workspace on paper via your printer, then it will return to the program and reprompt you for an input. When you enter QUIT as an answer to the prompt, the program will exit.

Crypto.bas is not intended for rigorous code-breaking other than simple letter substitution, but it can be used to create cryptograms. By following the instructions on decoding a cryptogram, you enter the plain text in place of the coded text, then use the letter-substitution capabilities of this program to generate the desired cryptogram. (Use the program to decode your cryptogram and check that you haven't assigned the same letter for two letters or made some other error.)

WELCOME TO THE DISTRICT OF COLUMBIA.



To Solve an Anagram

Anagram.bas (listing 2) will accept a word that is three- to six-letters long, display all the possible combinations on the screen, or print them at your command. A two-letter word has two combinations that are easily visualized without the aid of a computer. But a seven-letter word has 5040 possible combinations, far too many to scan on paper or on your monitor. Thus, the SWAP command is used extensively to simplify the program and increase its speed. Without SWAP, the process of swapping A$ and B$ requires these three steps:

1. T$=A$
2. A$=B$
3. B$=T$

SWAP requires only one command

SWAP A$,B$

to accomplish the same thing.

It works like this: when a word is entered, its length is checked and each letter is assigned to the string variables A through F. If the entered word is less than three characters or more than six, you're reprompted to make another input.

A three-letter input will generate six combinations. A three-count FOR . . . NEXT loop with two internal swaps provides the six possible "words."

A four-letter input has 24 possible combinations. By running through the three-letter swap four times, you produce 24 combinations. This is accomplished by the routine beginning on line 300. It runs through the three-letter routine once, swaps A$ and D$, runs through again, does another swap, and repeats the process until we have all the combinations printed on the screen.

A five-letter combination produces five times the combinations that a four-letter combination does, so we run through the four-letter swap five times. A repeated swap of B$ and E$ each time produces the proper circular shifting of each letter in the group.

As you might have guessed, a six-letter combination can be accomplished by going through the five-letter swap six times, with the necessary swap between each run-through of the subroutines. Since 720 six-letter words cannot be displayed simultaneously, they are printed in six groups of 120 words each. After each group of 120 words is printed, the subroutine starting on line 620 freezes the display. This gives you the time to scan the screen for the desired word(s), and only by pressing the space bar can you go on to the next 120 combinations. The program lets you print the letter combinations on your printer by answering the prompt

PRINTED COPY (Y/N):

with a Y. Any other response is accepted as a no. And as with Crypto.bas, Anagram.bas can also be used to create encoded words.

With these two programs, Anagram.bas and Crypto.bas, I hope you'll find that your decoding tasks are easier. Understandably, there will be a few purists who dislike using a computer to decipher anagrams, and I won't argue with them. It depends on your purposes for attempting to solve puzzles. Using a computer to solve a cryptogram, however, doesn't prevent the human intellect from participating in the process; it only removes the drudgery.

As a final word, I'll leave you with a cryptogram to test both the program and your decoding skills.

YJMQ CJDYANQR AS ZJJEAYW SJ HJRK SWQYQ TIOOEQY, HWAEQ JSWQRY TRQZQR BDBGRBMY BDN CRJYYHJRNY. A EAKQ SWQM BEE BDN WJTQ SWBS PJI WBN YJMQ ZID HASW SWAY QBYP JDQ. (Answer on page 468).■

Listing 2: *Anagram.bas is a BASIC program to decipher and create anagrams.*

```
10 'ANAGRAM6.BAS          *** ACCEPTS 3,4,5,& 6 CHARACTER GROUPS
20 '                      *** & PRINTS ALL POSSIBLE COMBINATIONS.
30 PRINT:PRINT:PF=0                                'PF=PRINT FLAG
40 INPUT"ENTER A WORD  (X to eXit program) ";W$
50 IF W$="X" THEN END                              ''X' EXITS FROM PROGRAM
60 INPUT"PRINTED COPY (Y/N):";P$
70 IF P$="Y" THEN PF=1:LPRINT W$                   'ANYTHING BUT 'Y'=NO
80 IF LEN(W$)<3 THEN 30                            'LESS THAN 3 IS TOO FEW
90 IF LEN(W$)>6 THEN 30                            'MORE THAN 6 IS TOO MANY
100 '    *** ASSIGN A$-F$ FOR THE UP-TO-SIX CHARACTERS OF W$ ***
110 A$=MID$(W$,1,1):B$=MID$(W$,2,1):C$=MID$(W$,3,1)
120 D$=MID$(W$,4,1):E$=MID$(W$,5,1):F$=MID$(W$,6,1)
130 IF LEN(W$)=3 THEN GOSUB 400:GOTO 30            'FIGURE LENGTH OF W$,
140 IF LEN(W$)=4 THEN GOSUB 300:GOTO 30            'THEN GOSUB AND SWAP.
150 IF LEN(W$)=5 THEN GOSUB 200:GOTO 30
160 GOSUB 500:GOTO 30                              'LEN(W$)=6
200 FOR J=1 TO 5                                   '5-VARIABLE SWAP
210  SWAP B$,E$:GOSUB 300
220 NEXT J
230 RETURN
300 GOSUB 400                                      '4-VARIBALE SWAP
310 SWAP A$,D$:GOSUB 400
320 SWAP B$,D$:GOSUB 400
330 SWAP C$,D$:GOSUB 400
340 RETURN
400 FOR X=1 TO 3                                   '3-VARIABLE SWAP
410  SWAP B$,C$:PRINT A$;B$;C$;D$;E$;F$;"    ";
420   IF PF=1 THEN LPRINT A$;B$;C$;D$;E$;F$;"    ";
430  SWAP A$,C$:PRINT A$;B$;C$;D$;E$;F$;"    ";
440   IF PF=1 THEN LPRINT A$;B$;C$;D$;E$;F$;"    ";
450 NEXT X
460 IF PF=1 THEN LPRINT
470 PRINT:RETURN
500 GOSUB 200:GOSUB 620                            '6-VARIABLE SWAP
510 SWAP A$,F$:GOSUB 200:GOSUB 620
520 SWAP B$,F$:GOSUB 200:GOSUB 620
530 SWAP C$,F$:GOSUB 200:GOSUB 620
540 SWAP D$,F$:GOSUB 200:GOSUB 620
550 SWAP E$,F$:GOSUB 200:GOSUB 620
560 RETURN
600 '    *** FREEZE DISPLAY FOR 6-LETTER COMBINATION. ***
610 '    *** DISPLAYS 120 COMBINATIONS AT A TIME. ***
620 PRINT:PRINT"PRESS <SP> TO CONTINUE."           '<SP>=SPACE BAR.
630 IN$=INKEY$                                     'LOOKS FOR A PRESSED
640 IF IN$=CHR$(32) THEN PRINT CHR$(12):RETURN     'SPACE BAR BEFORE
650 GOTO 630                                       'CLS AND RETURN.
```

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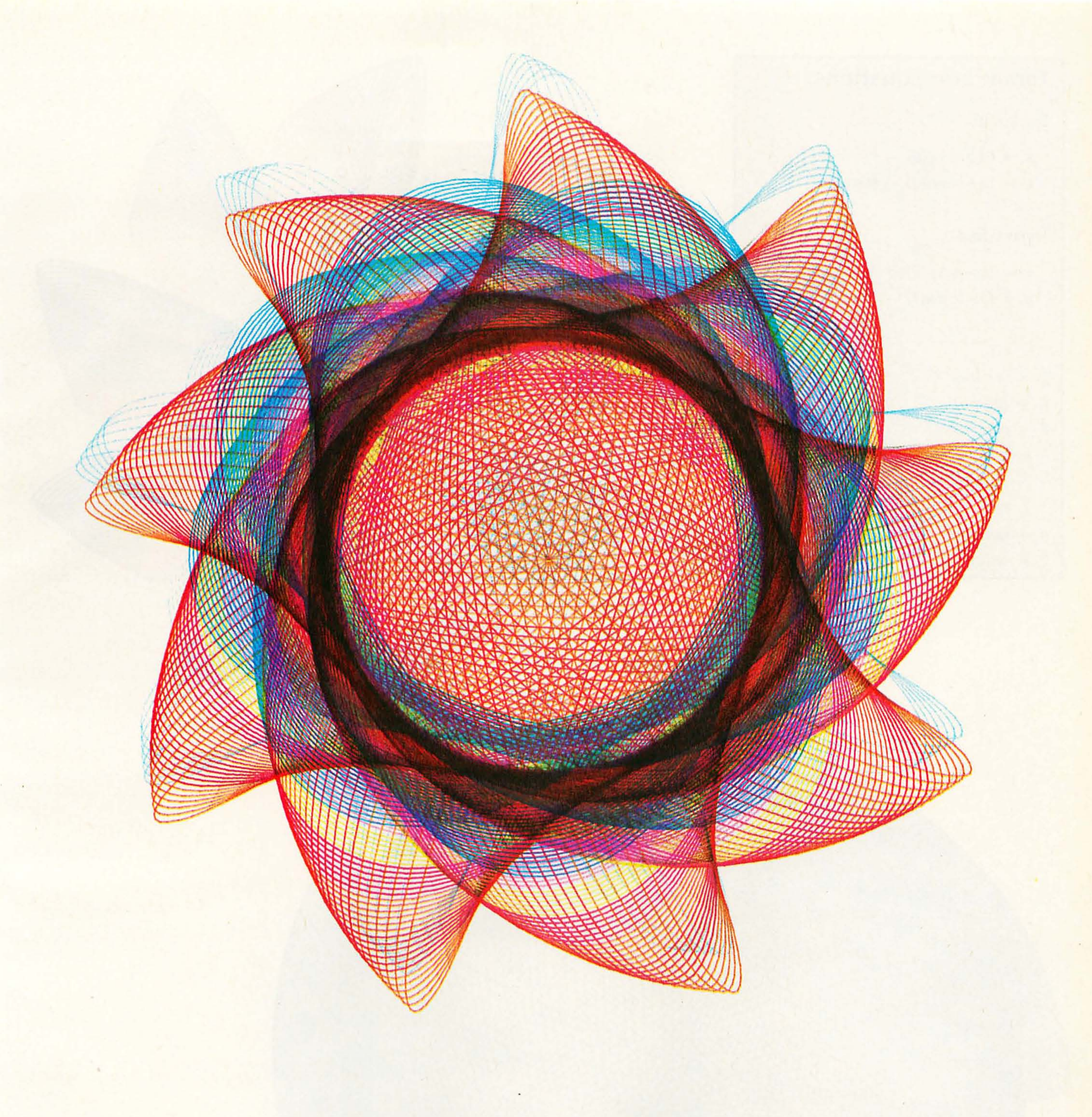


Five Original Graphics

Improving on the Spirograph

by Robert Sussman and Ted Sussman

Aesthetically pleasing graphic designs can be produced using mathematical curves—specifically, those called hypocycloid and epicycloid. One way to construct them is to use (by hand) physical templates to form combinations of these curves. This approach formed the basis for the popular toy Spirograph. A second method is to plot them, point by point, and, using a ruler, connect adjacent points to approach the true mathematical shape. We used a third method—computer graphics. This ar-



ticle outlines the computer-graphics method and illustrates some of its results.

The epicycloid is a curve described by a point on the circumference of a circle as the circle rolls, without slipping, on the outside of a fixed circle. The hypocycloid is a curve described by a point on the circumference of a circle as the circle rolls, without slipping, on the inside of a fixed circle. Their equations are given in parametric form in the text box on page 390. They are abstracted from Murray R. Spiegel's *Mathematical Handbook of Formulas and Tables*, McGraw-Hill Schaum's Outline Series, 1968, page 42.

To best appreciate and understand the computer method, it is instructive to simulate it by hand using the second method. The independent parameter—θ—is assigned successively larger values, at a fixed step size, and the x and y coordinates of the cycloid are calculated and plotted. The adjacent points are then connected by straight lines, thereby obtaining an approximation to the true mathematical curve.

As an example, figure 1 shows the construction of a hypocycloid using circles in the ratio of 5 to 14. Because this figure was drawn by hand, a large parametric step size of 10 degrees was used in the construction. The points on this figure are numbered to show the development of the curve.

Notice that if θ is allowed to increase past a certain value, denoted by θ_{max}, the cusps will coincide. For

Parametric Equations

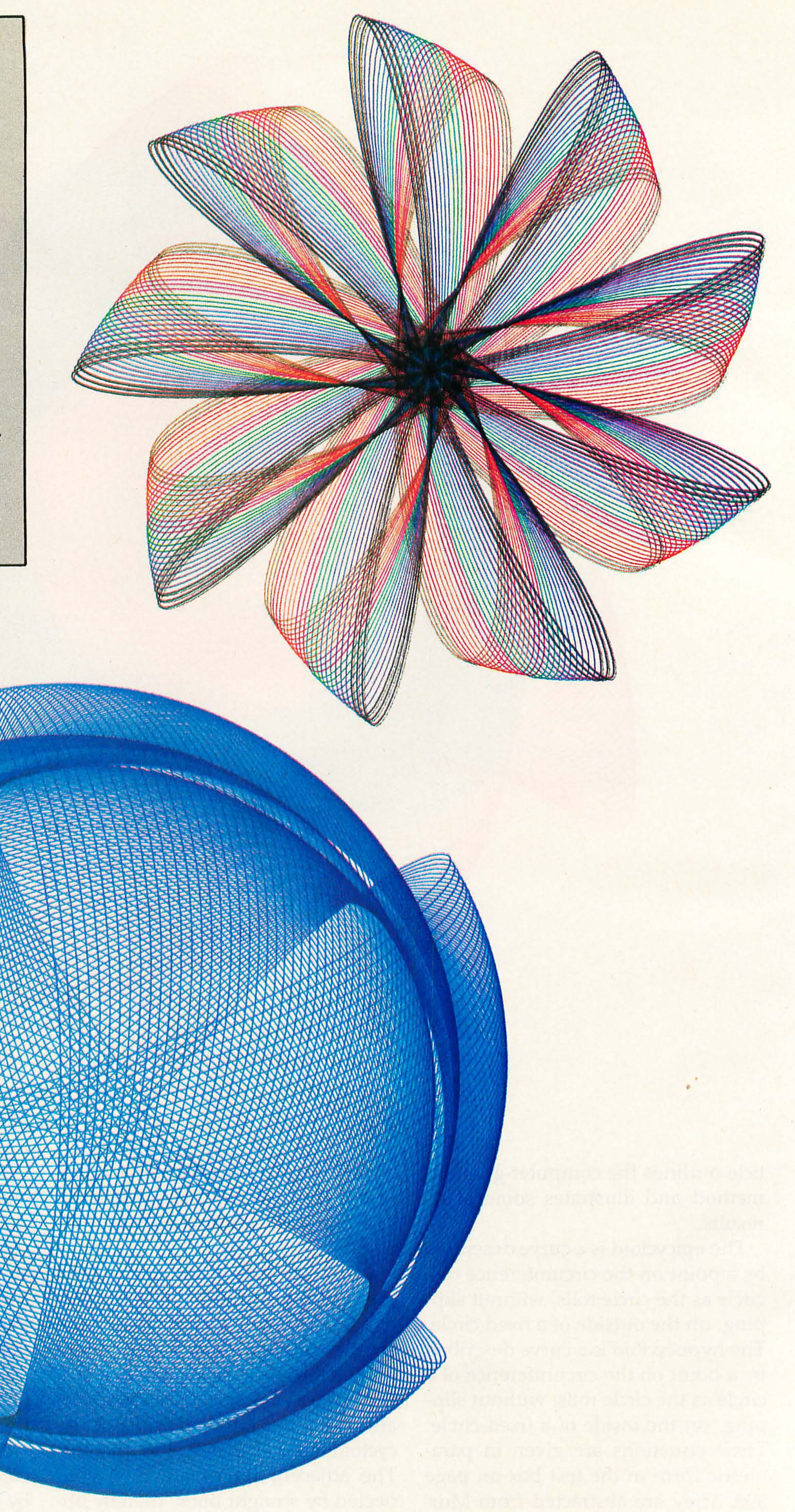
Epicycloid

$$x = (a+b)\cos(\theta) - b\cos(g\theta)$$
$$y = (a+b)\sin(\theta) - b\sin(g\theta)$$

Hypocycloid

$$x = (a-b)\cos(\theta) + b\cos(h\theta)$$
$$y = (a-b)\sin(\theta) - b\sin(h\theta)$$

$g = (a+b)/b$
$h = (a-b)/b$
θ = parameter
= angle between the x axis and the line connecting the two circles' centers
a = radius of fixed circle
b = radius of rolling circle



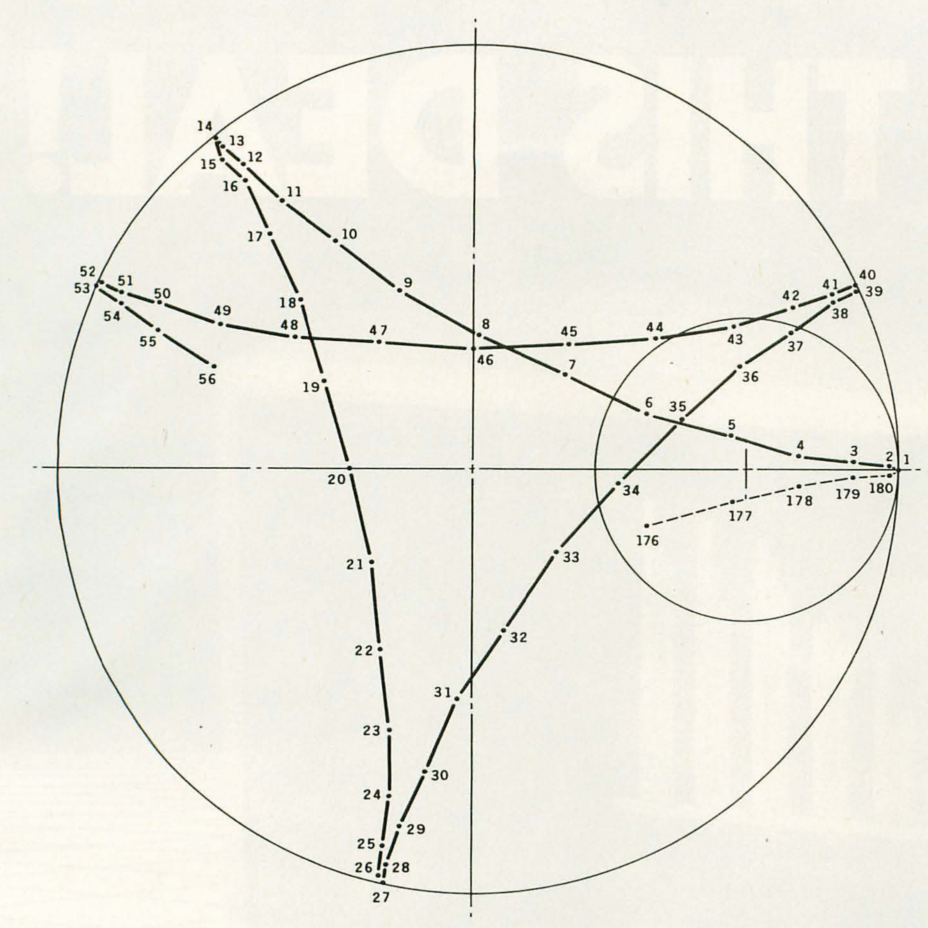


Figure 1: *An example of a handmade hypocycloid using the point-to-point technique described in the text.*

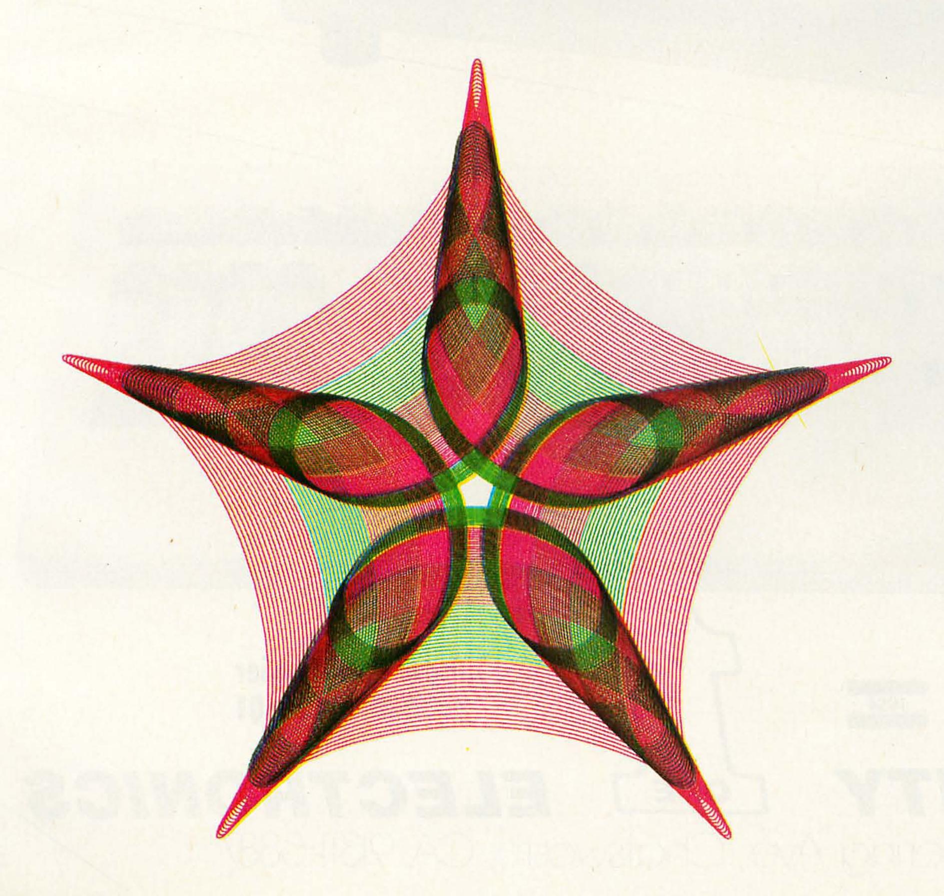


figure 1, θ_{max} equals 1,800 degrees. In general, θ_{max} is easily calculated given the radii of the circles; this permits you to predict the total number of points needed to draw the hypocycloid.

Additional properties of these curves can be developed to aid the designer in the choice of the values of the radii.

The computer permits the use of extremely small parametric step sizes resulting in points on the cycloids that are very close together. The computer connects these points by straight lines, but the illusion of a fully developed mathematical curve is created. In addition, many curves can be drawn quickly, giving the user many options for new designs.

But the most interesting aspects of using a computer to create these curves are those that extend the concept beyond what is possible with the first two methods. These extensions of the concept can be realized only using a computer. In general, these designs are sets of overlapping patterns. An example of this is shown in the first illustration on page 388. The program creates an initial pattern with and from initial parameters and linearly changes these parameters for successive patterns:

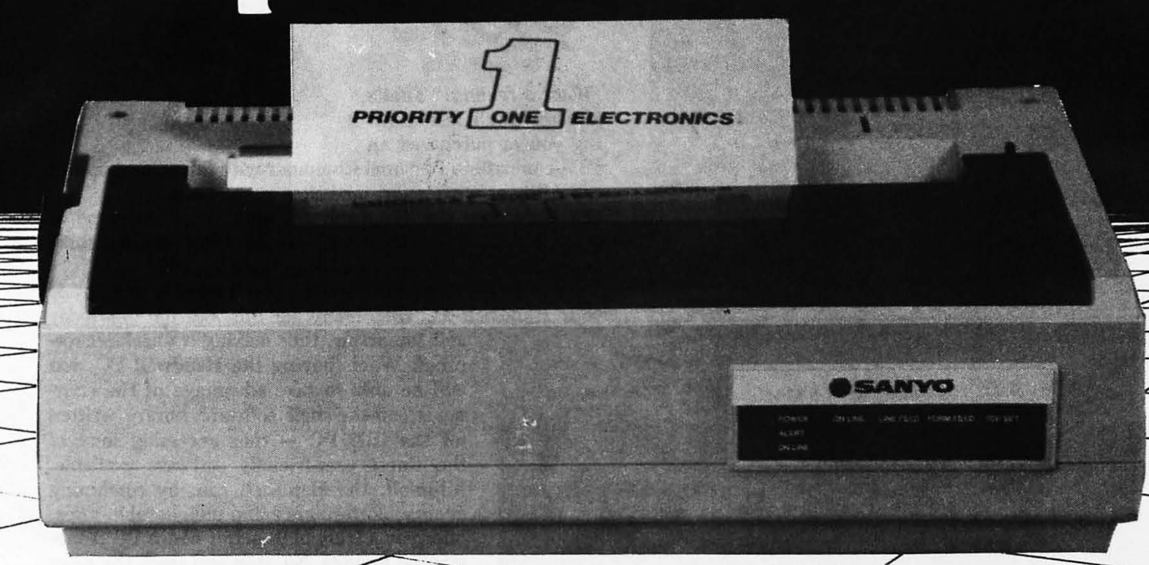
1. The location of the point on the rolling circle moves toward the circle's center as a function of the pattern number.
2. Each successive pattern is rotated a fixed number of degrees from the preceding one.
3. Each successive pattern is scaled to produce a zoom effect.

The five designs shown here are a small subset of all those possible using this technique. It requires your creative ability and artistic insight to use the computer to reveal *them.*■

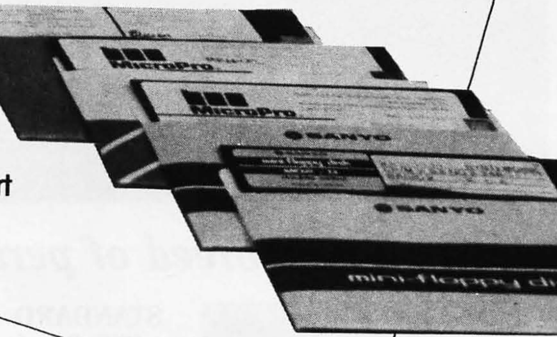
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Bubbles on the S-100 Bus

Part 2: The Software

Making Micropolis MDOS and CP/M work with last month's project

by Louis Wheeler

Author's Note: *Since this article was completed, Intel has revised the BPK 72 Bubble Memory Prototype Kit discussed in the Editor's Note at the end of part 1 of this article (BYTE, January 1984, page 380). As mentioned there, Intel is now offering the revised for for $199 as a promotional item. The new kit is completely assembled and tested at the factory and incorporates the latest version of the 7110 bubble-memory chip, which has been repackaged. The new chip is thinner, leaded, soldered directly to the printed-circuit board (permitting standard board spacing), requires a smaller board area, and is more reliable. Because the BPK 72 is already assembled and tested, those portions of part 1 relating to its testing can be skipped unless problems occur. The new kit is also equipped with an on-board clock oscillator that eliminates the need for the clock circuit, IC1, IC3, the 8-MHz crystal, and associated components, shown in the schematic diagram (figure 2). The* BPK 72 Bubble Memory Prototype Kit User's Manual *also has been revised to incorporate the information previously found in application note AP-119. A new application note, AP-150, containing a set of subroutines written in 8085 assembly language that demonstrates the basics of bubble-memory software design, is supplied with the kit. Although no longer needed, the much revised user's manual has eight pages of assembly instructions similar to those that come with a Heathkit. The new manual is a great improvement over the earlier documentation.*

Last month, we built and completed preliminary testing on the bubble-memory board. In this concluding part, we'll dive into the software and discuss the details of making the magnetic bubbles act like a floppy-disk drive or cache memory.

Before you proceed with the upcoming software, be sure all previous tests have been successful. Then discard the BASIC test routines.

Bubble-Memory-Driver Package

The application note supplied with the kit contains a set of subroutines to drive the BPK 72 bubble memory. These subroutines demonstrate the basics of bubble-memory software design. The bubble-memory-driver package (see listing 1) is based on the principles derived from this set of subroutines and the user's manual. I have been using it for some time now without any problems.

Before I get into the details of the driver package, I will give a brief description of the environment for which it was written. My system consists of an IMSAI (S-100 type) computer with a Z80 microprocessor, 56K bytes of RAM (random-access read/write memory), 2K bytes of EEPROM (electrically erasable programmable read-only memory), a Micropolis Mod II dual-disk-drive system (77 tracks, 16 sectors per track, 256 bytes per sector), a Z-19 terminal, and a printer. I have two operating systems: the Micropolis disk operating system (MDOS), which came with the floppy-disk system, and a recently acquired CP/M system.

Most of my applications software is written in Micropolis BASIC, which uses the MDOS resident I/O (input/output) package called Res. Res is something like CP/M BDOS (basic disk operating system) and BIOS (basic input/output system) combined. MDOS is a more sophisticated operating system than CP/M, but it cannot be modified as easily as the CP/M system with its BIOS module. The bubble-memory-driver package I am about to discuss functions with either of these operating systems. Given the proper linkage routine, it can probably be used with any operating system running an 8080, 8085, or Z80. Linkage routines and installation procedures for both MDOS and CP/M will be covered later.

The bubble-memory-driver package in listing 1 can be located anywhere in memory. Since it is only 220 bytes long, I placed it in EEPROM along with my system monitor *and* other peripheral drivers. The package provides six bubble-memory functions: (1) initialization, (2) general control operations, (3) reading of data, (4) writing of data, (5) reading the FIFO (first-in/first-out) buffer, and (6) writing 42 bytes to the FIFO buffer. Functions 2, 5, and 6 are normally not required and can be deleted if you are short of space. (They were included for use in an as yet unwritten

diagnostic program; they might also prove useful for special applications.)

All functions (except number 2) use the same calling sequence. The control function requires the additional step of loading the C register with a 7220 Bubble-Memory-Controller (BMC) command code (see table 1). Normally, you just have to load the HL-register pair with the address of the parameter block (discussed below) and then call the desired function. On return, if an error has occurred, the Carry flag will be set. If needed, the BMC status code can always be found in the Status byte of the parameter block. I have yet to encounter an error during normal operation. For testing purposes, errors can easily be forced by first writing data without the automatic error-detection/correction bit being set and then reading the same data back with the bit set. The error-detection/correction option is selected with bit 6 in the Enable byte.

The parameter block includes the data necessary to set up the parametric registers in the 7220 BMC, the address of a user buffer long enough to store the data to be transferred to/from the bubble memory, and 1 byte to store the BMC status. This is a total of 10 bytes. The parameter block can be located anywhere in RAM. Also, because its address is provided with every call to the bubble-memory-driver package, it can be moved about. You can even have more than one block if circumstances dictate. For example, if two separate files are being accessed at the same time, it might be desirable to set up two parameter blocks, one for each file. In any case, once a parameter block has been initialized, only two of the parameters are normally updated: the starting page number, BEGADR, and the user buffer address, BUFADR.

The number of FSA (formatter/sense amplifier) channels, CANALS, will always be 1 (indicating two FSA channels); 0 specifies one FSA channel and is used only for testing. The bank-select parameter, MBMSEL, should always be 0 (anything else would indicate a multibank system). BLKLEN specifies the number of 64-

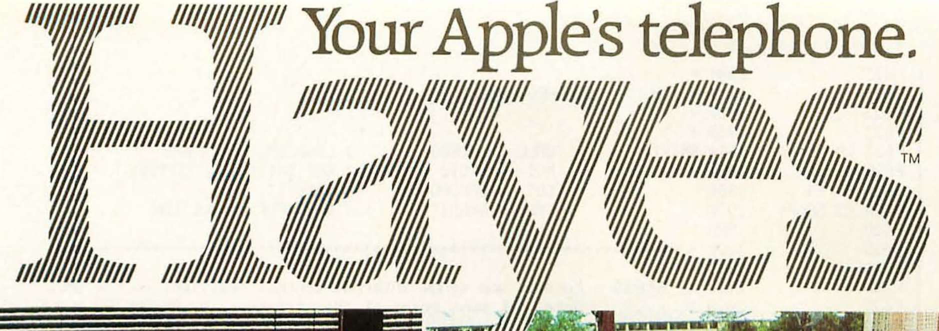
Text continued on page 402

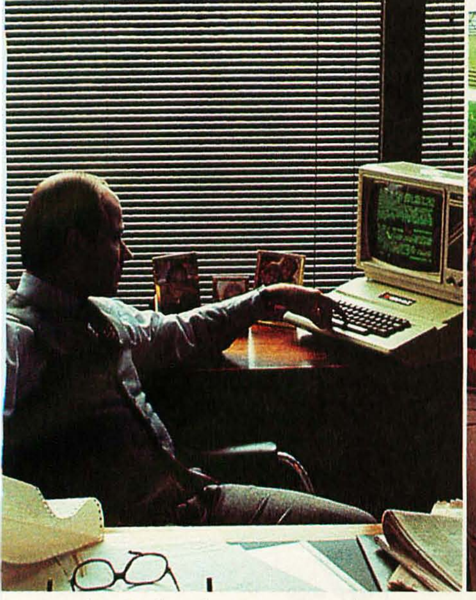
Listing 1: *The bubble-memory-driver package contains 8080/8085 assembly-language subroutines that can be set in ROM and linked with a disk operating system to enable the bubble memory to function as a disk-emulator or cache-memory system. The package requires 220 bytes of storage and can be located anywhere in memory.*

```
ADDR B1 B2 B3 E LINE LABEL          OPCD   OPERAND

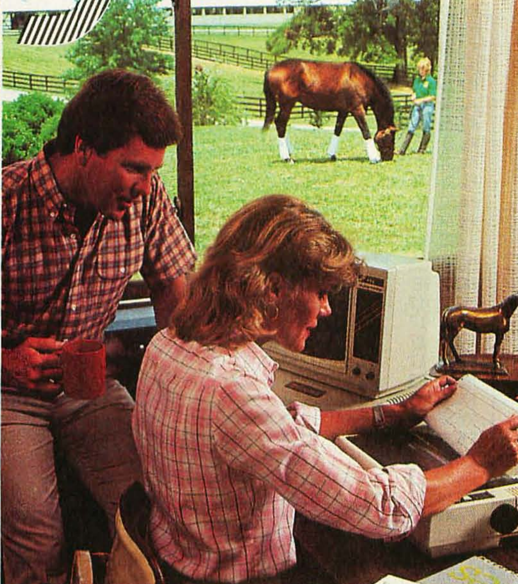
0000           * ****************************************************************
0000           *         INTEL BPK72 BUBBLE MEMORY DRIVER PACKAGE              *
0000           *                                                               *
0000           *              Copyright (C) 1983  Louis E. Wheeler             *
0000           * ****************************************************************
0000           *  The subroutines contained in this package provide the user with
0000           *  the basic functions needed to communicate with the INTEL BPK-72
0000           *  bubble memory system.  Before calling any of these functions
0000           *  the user must establish a PARAMETER BLOCK with the following
0000           *  parameters stored in the order shown:
0000           *   Name   (Bytes)   Function
0000           *
0000           *   BLKLEN (0-1)  =  Block length.  The number of 64 or 68 byte pages
0000           *                    to be transfered.  0 implies a 2048 page transfer.
0000           *   CANALS (2)    =  The number of FSA channels.  0 or 1.  Normally
0000           *                    1, indicating 2 FSA channels.
0000           *   ENABLE (3)    =  Defines various modes of operation for the
0000           *                    7220 controller.
0000           *   BEGADR (4-5)  =  Starting page number (address) for a transfer
0000           *                    block.
0000           *   MBMSEL (6)    =  Bank number of multibank systems.  Always 0
0000           *                    for single bank systems.
0000           *   BUFADR (7-8)  =  Address of user defined buffer.  Minimum size
0000           *                    64 bytes (depends on BLKLEN and ENABLE).
0000           *   STATUS (9)    =  Status byte returned after all calls.
0000           *
0000           *  The first five parameters are defined in the INTEL documentation.
0000           *  BUFADR points to a user supplied buffer with a minimum size of 64
0000           *  bytes.  The actual size depends on the block length in pages and
0000           *  whether or not automatic error correction has been selected in the
0000           *  ENABLE byte.  On return, the STATUS byte will contain the last
0000           *  BM status input from the BMC.  If an error condition existed,
0000           *  the C-flag will be set.
0000           *
0000           *  FUNCTIONS PROVIDED:
0000           *
0000           *         BMINIT  -  Initializes the bubble memory system
0000           *         BMCNTL  -  Performs non-data transfer control operations
0000           *         BMREAD  -  Reads one block (record) from bubble memory
0000           *         BMWRIT  -  Writes one block (record) to bubble memory
0000           *         RDFIFO  -  Reads content of FIFO buffer
0000           *         WRFIFO  -  Writes 42-bytes of data into FIFO buffer
0000           *
0000           *  CALLING SEQUENCE:
0000           *
0000           *         MVI C,[command]     Required for non-data transfer
0000           *                             control operations only.
0000           *         LXI H,PARAMBLK      HL = FWA of the above PARAMETER BLOCK
0000           *         CALL [function]     Any of the above functions
0000           *         JC ERROR            Transfer to user defined error routine
0000           *
0000           * ****************************************************************
0000           *
0000                                ORG    0F623H         ; A place to put it.
F623           *
F623           * ****************************************************************
F623           *
F623           *  COMMAND CODES
F623           *
F623  0011       CIZ               EQU    11H            ; INITIALIZE
F623  0012       CRD               EQU    12H            ; READ
F623  0013       CWR               EQU    13H            ; WRITE
F623  0019       CAB               EQU    19H            ; ABORT
F623  001D       CFR               EQU    1DH            ; FIFO RESET
F623  001E       CPURG             EQU    1EH            ; MBM PURGE COMMAND
F623           *
F623           *  STATUS WORD BITS
F623           *
F623  0001       FIFOBT            EQU    01H            ; FIFO STATUS
F623  0040       OPDONE            EQU    40H            ; OPERATION COMPLETE
F623  0080       BUSYBT            EQU    80H            ; BUSY BIT
F623           *
F623           *  OTHER EQUATES
F623           *
F623  000B       REGB              EQU    0BH            ; FIRST BMC REG TO SET (BLKLEN)
F623  00FD       PTYMSK            EQU    0FDH           ; MASK FOR PARITY BIT
F623  003C       STATER            EQU    3CH            ; STATUS WRD ERR MSK IGNORE PTY
F623           *
F623           *  I/O PORT ADDRESS ASSIGNMENTS
F623           *
F623  00E1       BMSTAT            EQU    0E1H           ; STATUS PORT
F623  00E1       BMCOMD            EQU    0E1H           ; COMMAND PORT
F623  00E0       BMDATA            EQU    0E0H           ; DATA PORT
F623           *
F623           * ****************************************************************
F623           *
F623           *  BMINIT - Initializes the MBM system for operation as specified
F623           *           in the PARAMETER BLOCK supplied by the user.
```

Listing 1 continued on page 398

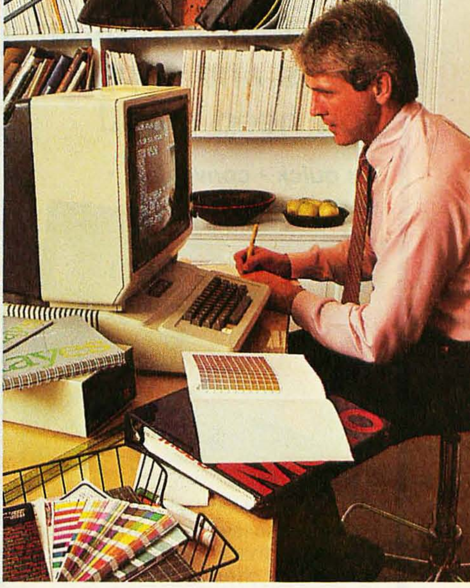




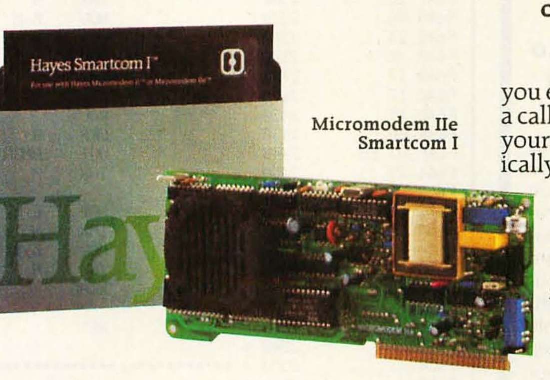
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Listing 1 continued:

```
F623                *
F623                *   CALLS:  SENDREG, BMEXIT
F623                *
F623                *
F623 CD 2D F6       BMINIT:        CALL    SNDREG          ; LOAD BMC REGISTERS
F626 3E 11                         MVI     A,CIZ           ; GET INITIALZIE COMMAND
F628 D3 E1                         OUT     BMCOMD          ; SEND IT.
F62A C3 58 F6                      JMP     BMEXIT          ; WAIT FOR COMPLETION
F62D                *
F62D                * ***********************************************************
F62D                *
F62D                *   SNDREG - Formats and sends internal control registers to the BMC.
F62D                *            Note:  HL must point ot the user supplied PARAMETER BLOCK.
F62D                *
F62D                *   CALLS:  None
F62D                *
F62D                *
F62D 3E 0B          SNDREG:        MVI     A,REGB          ; GET 1ST REG ADDRESS
F62F D3 E1                         OUT     BMCOMD          ; AND SEND IT.
F631                *
F631                *  CONSTRUCT AND SEND BLOCK LENGTH. [BLR]
F631                *
F631 7E                            MOV     A,M             ; GET BLKLEN (LSB)
F632 D3 E0                         OUT     BMDATA          ; SEND IT.  (BMC B-REG)
F634 23                            INX     H               ; BUMP ADDR
F635 46                            MOV     B,M             ; B=BLKLEN (MSB)
F636 23                            INX     H
F637 7E                            MOV     A,M             ; A=NUM OF FSA CHANNELS
F638 17                            RAL
F639 17                            RAL                     ; SHIFT LEFT 4-PLACES
F63A 17                            RAL
F63B 17                            RAL
F63C B0                            ORA     B               ; MELD WITH BLKLEN (MSB)
F63D D3 E0                         OUT     BMDATA          ; SEND IT.  (BMC C-REG)
F63F                *
F63F                * ENABLE BYTE.  [ER]
F63F                *
F63F 23                            INX     H               ; BUMP ADDR
F640 7E                            MOV     A,M             ; GET ENABLE BYTE
F641 D3 E0                         OUT     BMDATA          ; SEND IT.  (BMC D-REG)
F643                *
F643                * CONSTRUCT AND SEND ADDRESS REGISTER.  [AR]
F643                *
F643 23                            INX     H               ; BUMP ADDR
F644 7E                            MOV     A,M             ; A=ADDR REG (LSB)
F645 D3 E0                         OUT     BMDATA          ; SEND IT.  (BMC E-REG)
F647 23                            INX     H
F648 46                            MOV     B,M             ; B=ADDR REG (MSB)
F649 23                            INX     H
F64A 7E                            MOV     A,M             ; A=BUBBLE NUMBER
F64B 17                            RAL
F64C 17                            RAL                     ; SHIFT IT 3-PLACES
F64D 17                            RAL
F64E B0                            ORA     B               ; MELD WITH PAGE NUMBER (MSB)
F64F D3 E0                         OUT     BMDATA          ; SEND IT.  (BMC F-REG)
F651 23                            INX     H               ; BUMP ADDR
F652                *
F652 5E             SWAPREG:       MOV     E,M             ; GET USER BUFFER ADDR
F653 23                            INX     H               ; TO DE-REG
F654 56                            MOV     D,M             ; FOR LATER USE.
F655 23                            INX     H               ; BUMP PNTR TO STATUS ADDR.
F656 EB                            XCHG                    ; HL=POINTER TO USER BUFFER.
F657                *                                      ; DE=POINTER TO RETURN STATUS
F657 C9                            RET
F658                *
F658                * ***********************************************************
F658                *
F658                *   BMEXIT - Waits for completion of the current BMC operation and
F658                *            then checks for any error conditions.  If an error is
F658                *            indicated, the C-flag is set prior to exiting.  This
F658                *            routine serves as a common exit for all functions.
F658                *            Note: A busy condition that persists too long is considered
F658                *                  an error.  This might occur if the parameter block
F658                *                  is improperly constructed.
F658                *
F658                *   CALLS:  None
F658                *
F658                *
F658 01 FF FF       BMEXIT:        LXI     B,0FFFFH        ; SET UP TIMER.
F65B                *
F65B DB E1          BMEX1:         IN      BMSTAT          ; GET STATUS
F65D E6 FD                         ANI     PTVMSK          ; MASK OUT PTV ERR
F65F 12                            STAX    D               ; SAVE IT.
F660 F2 6C F6                      JP      BMEX2           ; NO, GO CK FOR ERRORS.
F663 0B                            DCX     B               ; ELSE, FOR JUST
F664 78                            MOV     A,B             ; SO MANY
F665 B1                            ORA     C               ; TIMES
F666 C2 5B F6                      JNZ     BMEX1           ; LOOP AND TRY AGAIN.
F669 C3 73 F6                      JMP     BMERRX          ; TOOK TOO LONG IF BC=0
F66C                *
F66C E6 3C          BMEX2:         ANI     STATER          ; WAS THERE AN ERROR?
F66E C2 73 F6                      JNZ     BMERRX          ; YES, TAKE ERROR EXIT.
F671 AF                            XRA     A               ; NO, CLEAR FLAG
F672 C9                            RET                     ; AND EXIT.
F673                *
F673 3E 19          BMERRX:        MVI     A,CAB           ; CLEAR THE RECKAGE
F675 D3 E1                         OUT     BMCOMD          ; BY ABORTING
```

Listing 1 continued on page 400

Gifford has a lock on multiuser CP/M® 8-16.

It's 11:00 P.M. Do you know where your files are?

It's great when multiple local and off site users can run any 8- or 16-bit CP/M or MP/M™ program. It's even better when they can share expensive resources like printers, hard disks, and tape drives. Best of all is when they can share your most precious resource—data. Gifford has been delivering systems with all these features for over two years.

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With our new security features, you can control what resources and data are shared.

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With our Virtual Terminals, each terminal on your system can monitor up to four different programs running concurrently. And at the touch of a key you can switch screens instantly from one program to another.

You could look up an address in dBASE II,™ jump over to SuperCalc™ to make some projections, then switch instantly to WordStar® to use this information to update a letter. If you forget what's on a screen, just touch a key to refresh your memory. You won't need to go through the distracting process of loading and unloading programs.

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Circle 151 on inquiry card.

Listing 1 continued:

```
F677 3E 1E              MVI   A,CPURG        ; AND PURGING
F679 D3 E1              OUT   BMCOMD         ; EVERYTHING.
F67B 37                 STC                  ; SET CARRY FLAG
F67C C9                 RET                  ; AND EXIT.
F67D          *
F67D          * ***************************************************************
F67D          *
F67D          *  BMCNTL - Facilitates direct user control of the MBM system through
F67D          *           command operations.  No data is transferred.  The routine
F67D          *           expects to find the COMMAND CODE in the C register.
F67D          *
F67D          *  CALLS:  SNDREG, BMEXIT
F67D          *
F67D CD 2D F6 BMCNTL:   CALL  SNDREG         ; LOAD BMC REGISTERS
F680 79                 MOV   A,C            ; GET COMMAND
F681 D3 E1              OUT   BMCOMD         ; INITIATE IT.
F683 C3 58 F6           JMP   BMEXIT         ; WAIT TILL DONE
F686          *
F686          * ***************************************************************
F686          *
F686          *  BMREAD - Reads one record as specified in the PARAMETER BLOCK.
F686          *           Note: Failure to provide sufficient buffer area can
F686          *           prove disastrous.
F686          *
F686          *  CALLS:  SNDREG, BMEXIT
F686          *
F686          *
F686 3E 1D    BMREAD:   MVI   A,CFR          ; RESET FIFO
F688 D3 E1              OUT   BMCOMD
F68A CD 2D F6           CALL  SNDREG         ; SEND REG'S TO BMC
F68D 3E 12              MVI   A,CRD          ; INITIATE READ
F68F D3 E1              OUT   BMCOMD         ; OPERATION.
F691          *
F691 DB E1    BMRD1:    IN    BMSTAT         ; GET STATUS
F693 B7                 ORA   A              ; WAIT FOR BUSY
F694 F2 91 F6           JP    BMRD1          ; LOOP UNTIL SET.
F697          *
F697 DB E1    BMRD2:    IN    BMSTAT         ; GET STATUS
F699 B7                 ORA   A              ; BUSY ?
F69A F2 58 F6           JP    BMEXIT         ; NOPE, ALL DONE.
F69D E6 01              ANI   FIFOBT         ; FIFO EMPTY?
F69F CA 97 F6           JZ    BMRD2          ; YEP, GO CK BUSY
F6A2 DB E0              IN    BMDATA         ; NOPE, GET THE DATA
F6A4 77                 MOV   M,A            ; STORE IT
F6A5 23                 INX   H              ; BUMP STORE ADDR
F6A6 C3 97 F6           JMP   BMRD2          ; AND LOOP FOR MORE.
F6A9          *
F6A9          * ***************************************************************
F6A9          *
F6A9          *  BMWRIT - Writes one record to the BM.  Note: records shorter
F6A9          *           than the block size specified in the PARAMETER BLOCK
F6A9          *           should be padded with a suitable character, else the
F6A9          *           record will be filled out with what ever is availbable.
F6A9          *
F6A9          *  CALLS:  SNDREG, BMEXIT, BMERRX
F6A9          *
F6A9          *
F6A9 3E 1D    BMWRIT:   MVI   A,CFR          ; GET FIFO RESET
F6AB D3 E1              OUT   BMCOMD         ; SEND IT.
F6AD CD 2D F6           CALL  SNDREG         ; SEND REG'S
F6B0 3E 13              MVI   A,CWR          ; GET WRITE COMMAND
F6B2 D3 E1              OUT   BMCOMD         ; SEND IT.
F6B4          *
F6B4 DB E1    BMWR1:    IN    BMSTAT         ; GET STATUS
F6B6 E6 81              ANI   BUSYBT+FIFOBT  ; WAIT FOR BUSY
F6B8 FE 81              CPI   BUSYBT+FIFOBT  ; AND FIFO BITS.
F6BA C2 B4 F6           JNZ   BMWR1          ; LOOP UNTIL...
F6BD          *
F6BD DB E1    BMWR2:    IN    BMSTAT         ; GET STATUS
F6BF E6 FD              ANI   PTYMSK         ; MASK OUT PTY ERR
F6C1 12                 STAX  D              ; SAVE IN E-REG
F6C2 F2 D1 F6           JP    BMWR3          ; OP COMPLETE/FAILED?
F6C5 E6 01              ANI   FIFOBT         ; FIFO READY?
F6C7 CA BD F6           JZ    BMWR2          ; NOPE, LOOP TRY AGN.
F6CA 7E                 MOV   A,M            ; YES LOAD SOME DATA
F6CB D3 E0              OUT   BMDATA         ; GIVE IT TO BMC
F6CD 23                 INX   H              ; BUMP ADDR
F6CE C3 BD F6           JMP   BMWR2          ; AND LOOP FOR MORE.
F6D1          *
F6D1 1A       BMWR3:    LDAX  D              ; GET STATUS
F6D2 FE 41              CPI   OPDONE+FIFOBT  ; ALL DONE AND GOOD?
F6D4 CA 58 F6           JZ    BMEXIT         ; NORMAL EXIT.
F6D7 C3 73 F6           JMP   BMERRX         ; ERROR EXIT
F6DA          *
F6DA          * ***************************************************************
F6DA          *
F6DA          *  RDFIFO - Reads the contents of the FIFO buffer.
F6DA          *
F6DA          *  CALLS:  SWAPREG, BMEXIT
F6DA          *
F6DA          *
F6DA 11 07 00 RDFIFO:   LXI   D,0007H        ; POSITION PARAMBLK PNTR
F6DD 19                 DAD   D              ; TO USER BUFFER ADDR.
F6DE CD 52 F6           CALL  SWAPREG        ; SET UP HL/DE POINTERS.
F6E1          *
F6E1 DB E1    RDFIFO2:  IN    BMSTAT         ; GET STATUS
F6E3 E6 01              ANI   FIFOBT         ; ANY DATA THERE?
```

Listing 1 continued on page 402

For dealer locations, see page 439.

Circle 67 on inquiry card.

Text continued from page 396:

byte blocks to be transferred in one operation. For the 128-byte records used by CP/M, BLKLEN is set to 2. For MDOS, which uses 256-byte records, BLKLEN is set to 4. A BLKLEN of 0 implies a block length of 2048. The Status byte need not be initialized.

Using the driver package with an assembly-language program is not difficult. Just set up the parameter block, load the address of the parameter block into the HL-register pair, and call the desired function. Although linking the bubble-memory-driver package with an operating system is also fairly straightforward, it does require some knowledge of the interworkings of the operating system involved.

MDOS Linkage

Linking the driver package to the Micropolis operating system was somewhat simpler than it was with CP/M. This is partly true because the MDOS linkage (see listing 2) is not a complete disk emulation; it functions more like a cache memory than a disk. Although it lets you access the bubble memory with BASIC disk commands (OPEN, CLOSE, GET, PUT, etc.), it has no directory, and, if more than one file is to be maintained, it is your responsibility to keep track of where the files are located. I chose this approach for two reasons: (1) MDOS does not readily lend itself to this type of modification, and (2) it is more in keeping with my intended application—to provide my text editor with a large, fast, yet nonvolatile storage medium. The editor uses the bubble memory as though it were disk 3 with a capacity of more than 30 typewritten pages. It treats the bubble memory like a temporary working file, using a floppy-disk file for permanent storage. I intend to use it for other large files where rapid access is a factor, such as a checkbook file.

The preceding approach simplifies the modification of MDOS and still produces the desired results. There is room in the Res module to accommodate the added code. The only patch necessary is at the point where Res determines if the disk number is

Text continued on page 406

Listing 1 continued:

```
F6E5 CA 58 F6                   JZ    BMEXIT      ; NO, EXIT.
F6E8 DB E0                      IN    BMDATA      ; YES, GET DATA
F6EA 77                         MOV   M,A         ; STORE IT
F6EB 23                         INX   H           ; BUMP STORE ADDR
F6EC C3 E1 F6                   JMP   RDFIFO2     ; LOOP FOR MORE.
F6EF          *
F6EF          * ****************************************************************
F6EF          *
F6EF          *  WRFIFO - Sends 42 bytes to the FIFO buffer.
F6EF          *
F6EF          *  CALLS:  SNDREG, BMEXIT
F6EF          *
F6EF          *
F6EF CD 2D F6 WRFIFO:           CALL  SNDREG      ; SEND REG'S
F6F2 0E 2A                      MVI   C,42        ; SET CNT FOR 42 BYTES
F6F4 7E       WRFIFO2:          MOV   A,M         ; GET SOME DATA
F6F5 D3 E0                      OUT   BMDATA      ; SEND IT
F6F7 23                         INX   H           ; BUMP LOAD ADDR
F6F8 0D                         DCR   C           ; COUNT IT AND
F6F9 C2 F4 F6                   JNZ   WRFIFO2     ; LOOP IF NOT DONE.
F6FC C3 58 F6                   JMP   BMEXIT      ; EXIT.
F6FF          *

ERRORS THIS ASSEMBLY  0000
```

Command Code (hexadecimal)	Command/Explanation
10	WRITE BOOT LOOP REGISTER MASKED. Can be used in place of the WRITE BOOT LOOP REGISTER command. Masks out any trailing 1s.
11	INITIALIZE. Reads and decodes the boot loop from the MBM and stores the result in the FSA's boot-loop register. Does not alter any data stored in the MBM.
12	READ BUBBLE DATA. Causes data to be read from the MBM into the BMC FIFO buffer. All parametric registers must be set up prior to issuing this command.
13	WRITE BUBBLE DATA. Causes data to be transferred from the BMC FIFO buffer to the MBM. All parametric registers must be set up prior to issuing this command.
14	READ SEEK. Rotates the MBM to an address designated in the parametric register. Can be used to reduce access time. After this command, the parametric registers must be reset.
15	READ BOOT LOOP REGISTER. Causes the BMC to read the boot-loop register of the selected FSA channels into the BMC FIFO buffer.
16	WRITE BOOT LOOP REGISTER. Causes the BMC to write the contents of the BMC FIFO buffer into the selected FSA channels. The data must have been previously written into the FIFO buffer.
17	WRITE BOOT LOOP. Causes the existing contents of the MBM's boot loop to be replaced with 40 bytes taken from the BMC FIFO buffer. *Caution—execution of this command destroys the boot loop written into the MBM at the factory.* This command cannot be executed until the Write Boot Loop Enable bit has been set in the Enable register.
18	READ FSA STATUS. Causes the BMC to read the 8-bit status register of all FSAs and stores it in the BMC FIFO buffer.
19	ABORT. Terminates any command currently being executed. If the BMC is busy when executed, this command must be followed by an INITIALIZE or MBM PURGE command.
1A	WRITE SEEK. Rotates the MBM to a designated address location. After a WRITE SEEK command is executed, the parametric registers must be reset. Can be used to reduce access time.
1B	READ BOOT LOOP. Causes the BMC to read the boot loop from the MBM into the BMC FIFO buffer. Must be preceded by a FIFO RESET command.
1C	READ CORRECTED DATA. Causes the BMC to read into the FIFO buffer a 64-byte block of data after the FSA has attempted to correct the data. The FSA informs the BMC whether the error was correctable or not. The command is used only when the system is in the error-correction mode enabled in the Enable register.
1D	RESET FIFO. Clears the BMC FIFO buffer and all I/O latches.
1E	MBM PURGE. Clears all BMC registers, counters, and the MBM address. Does not clear the block-length register, FSA counter, or the 4 high-level bits of the address register.
1F	SOFTWARE RESET. Clears the BMC FIFO and all registers except parameters. No INITIALIZATION command is required after this command.

Table 1: *A list of 7220 Bubble-Memory-Controller command codes. Each code is further explained in the* BPK 72 Bubble Memory Prototype Kit User's Manual *supplied with the kit.*

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- 13″ RGB 399

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- KG12″ Green $169
- RGBvision 1 Color 315

Zenith
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- 122 12″ Amber 145
- 131 Med. Res. RGB 319
- 135 High Res. RGB 549

BMC
- 12AU 12″ Gr. $85

Nec
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- JB1205 169
- JC1216 469

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- CRT-7 RGB Color Call

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- 1200B (IBM-PC) ... 499
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- Volksmodem ... 59.95

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- J-Cat 110.00
- Apple Cat II 279
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Listing 2: *The MDOS bubble-memory-driver linkage modifies the MDOS Res module to allow Micropolis BASIC to access the bubble memory as a cache memory. The modification can be installed using the MDOS LOAD command.*

```
ADDR B1 B2 B3 E LINE LABEL          OPCD   OPERAND

0000            * ***********************************************************
0000            *                  MDOS RES - BUBBLE DRIVER LINKAGE          *
0000            *                                                            *
0000            *               Copyright (C) 1983  Louis E. Wheeler         *
0000            * ***********************************************************
0000                                ORG    2B00H        ; DUMMY ORG FOR LOADER
2B00 00                             NOP
2B01            *
2B01                                ORG    0968H        ; UNIT NUMBER CK PATCH
0968            *
0968 FE 02                          CPI    02H          ; CHECK LEGAL DRIVE
096A D2 00 07                       JNC    BUBRES       ; NO, ITS A BUBBLE.
096D            *
096D                                ORG    06FEH        ; FIX FOR PRINTER INIT.
06FE AF                             XRA    A
06FF C9                             RET
0700            *
0700            *  RESIDENT INTERFACE FOR BUBBLE MEMORY DRIVERS
0700            *
0700            *
0700            *  SYSTEM EQUATES:  (BM function addr's equate to EEPROM jump table)
0700            *
0700    F018    @BMINIT             EQU    0F018H       ; INITIALIZE BUBBLE MEMORY
0700    F01B    @BMREAD             EQU    0F01BH       ; READ BUBBLE MEMORY RECORD
0700    F01E    @BMWRIT             EQU    0F01EH       ; WRITE BUBBLE MEMORY RECORD
0700            *
0700    0004    SBLKLEN             EQU    0004H        ; BLOCK LENGTH=4 PAGES
0700    0001    SCANALS             EQU    01H          ; NUMBER OF FSA CHNLS=2
0700    0020    SENABLE             EQU    20H          ; ENABLE BYTE=RCD & HI-SPD
0700    0000    SBEGADR             EQU    0000H        ; BEGIN ADDR=PAGE 0
0700    0000    SMEMSEL             EQU    00H          ; BUBBLE NUM SELECT=FIRST
0700            *
0700            *
0700 3A 21 12   BUBRES:             LDA    1221H        ; GET 1ST CODE
0703 B7                             ORA    A            ; IF CODE =
0704 CA 14 07                       JZ     BINOUT       ; 00 - GO CK 2ND CODE
0707 FE 04                          CPI    04H
0709 CA 26 07                       JZ     BOPEN        ; 04 - IT'S AN OPEN
070C FE 08                          CPI    08H
070E CA 32 07                       JZ     BCLOSE       ; 08 - IT'S A CLOSE
0711 C3 F4 0F                       JMP    0FF4H        ; "PARM ERROR" EXIT.
0714            *
0714 1E 03      BINOUT:             MVI    E,3          ; ERR RETRY CNT
0716 3A 22 12                       LDA    1222H        ; GET 2ND CODE
0719 FE 06                          CPI    06H
071B CA 49 07                       JZ     BPUT         ; 06 - IT'S A PUT
071E FE 09                          CPI    09H
0720 CA 39 07                       JZ     BGET         ; 09 - IT'S A GET
0723 C3 F4 0F                       JMP    0FF4H        ; "PARM ERROR" EXIT.
0726            *
0726 32 38 07   BOPEN:              STA    OCFLAG       ; SET OPEN FLAG
0729 CD 7E 06                       CALL   INITPB       ; INITIALIZE PARAM BLOCK
072C CD 18 F0                       CALL   @BMINIT      ; GO INITIALIZE BUB MEM
072F C3 FC 09                       JMP    09FCH        ; EXIT
0732            *
0732 32 38 07   BCLOSE:             STA    OCFLAG       ; SET CLOSE FLAG
0735 C3 FC 09                       JMP    09FCH        ; EXIT
0738            *
0738 08         OCFLAG:             DB     08H          ; OPEN/CLOSE FLAG
0739            *                                       ; 04 = OPEN  08 = CLOSED
0739            *
0739 CD 59 07   BGET:               CALL   BSETUP       ; GO SET UP CNTL BLK
073C CD 1B F0   BRDRPT:             CALL   @BMREAD      ; GO READ REC
073F D2 FC 09                       JNC    09FCH        ; GOOD READ, EXIT.
0742 1D                             DCR    E            ; BUMP RETRY CNT
0743 C2 3C 07                       JNZ    BRDRPT       ; TRY ONCE AGAIN.
0746 C3 FA 0F                       JMP    0FFAH        ; "PERM ERROR" EXIT.
0749            *
0749 CD 59 07   BPUT:               CALL   BSETUP       ; GO SET UP CNTL BLK
074C CD 1E F0   BWRRPT:             CALL   @BMWRIT      ; GO WRITE REC
074F D2 FC 09                       JNC    09FCH        ; GOOD PUT, EXIT.
0752 1D                             DCR    E            ; BUMP RETRY CNT
0753 C2 4C 07                       JNZ    BWRRPT       ; TRY ONCE AGAIN.
0756 C3 FA 0F                       JMP    0FFAH        ; "PERM ERROR" EXIT.
0759            *
0759            *
0759 3A 38 07   BSETUP:             LDA    OCFLAG       ; CK FILE OPEN
075C FE 04                          CPI    04H
075E CA 65 07                       JZ     SETREC       ; YES, GO ON.
0761 E1                             POP    H            ; CLEAR STACK
0762 C3 00 10                       JMP    1000H        ; "FILE NOT OPEN" EXIT.
0765 2A 27 12   SETREC:             LHLD   1227H        ; SET UP REC #
0768 29                             DAD    H            ; MULTIPLY BY 4
0769 29                             DAD    H            ; (64 X 4 = 256 BYTES)
076A 22 A0 06                       SHLD   BEGADR       ; PLACE IN PARAM BLOCK
076D 2A 23 12                       LHLD   1223H        ; GET BUF ADDR
0770 22 A3 06                       SHLD   BUFADR       ; PLACE IN PARAM BLOCK
0773 21 9C 06                       LXI    H,PARAMBLK   ; HL=PARAMETER BLOCK FWA
0776 C9                             RET
0777            *
```

Listing 2 continued on page 406

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Circle 215 on inquiry card.

Text continued from page 402:

legal. The jump-to-error routine was changed to jump to the bubble-linkage code. Thus, the Res module now assumes that a disk number greater than 2 is not an error but a bubble-memory request.

The linkage itself is straightforward. Similar to BDOS calls in CP/M, MDOS uses a code to determine the intended disk function. However, it is a 2-byte code stored in hexadecimal locations 1221 and 1222. Only the codes for OPEN, CLOSE, PUT, and GET have been decoded. Any other code is interpreted as a Parm Error, and the appropriate error exit is taken. OPEN causes the parameter block to be initialized, then calls the BMINIT driver routine to initialize the bubble memory. GET and PUT call the appropriate driver routines. If the Carry flag is set on return from either the BMREAD or BMWRITE routines, indicating that an error did occur, three attempts are made to perform the I/O function correctly before taking a Perm-Error exit.

Actual installation of the linkage is quite simple. With the bubble-memory-driver package already in PROM (programmable read-only memory) or elsewhere in memory, it is necessary only to assemble the linkage and then use the system's LOAD command to overlay the Res module. The bubble-memory exerciser program in listing 3 can then be used to test the installation and the bubble memory. Written in Micropolis BASIC, it reads and writes single records or blocks of records. It also incorporates a test routine that writes a predefined record, then reads it back and compares it with the data that was written. It also checks the bubble-memory status. Testing the whole bubble memory of 511 records takes about 114 seconds (using a Z80 with a 4-MHz clock). For comparison, I ran the same program (slightly modified) using the floppy-disk memory; it took 368 seconds, or roughly three times as long.

One other note. Because there is no directory, it is not necessary to format or initialize the bubble memory before writing to it. The BMINIT subroutine does not change any data stored in the bubble memory. It

Text continued on page 412

Listing 2 continued:

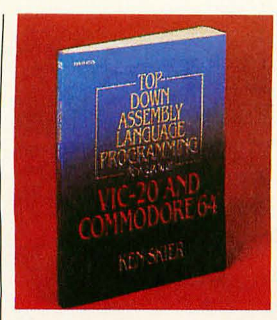
```
0777            *
0777                          ORG    067EH         ; AN EMPTY AREA . . .
067E            *
067E            *
067E 21 04 00   INITPB:       LXI    H,SBLKLEN     ; SET BLOCK LENGTH
0681 22 9C 06                 SHLD   BLKLEN
0684            *
0684 3E 01                    MVI    A,SCANALS     ; SET NUMBER FSA CHANNELS
0686 32 9E 06                 STA    CANALS
0689            *
0689 3E 20                    MVI    A,SENABLE     ; SET ENABLE BYTE
068B 32 9F 06                 STA    ENABLE
068E            *
068E 21 00 00                 LXI    H,SBEGADR     ; SET BEGINNING PAGE NO.
0691 22 A0 06                 SHLD   BEGADR
0694            *
0694 AF                       XRA    A             ; SET BM BANK SELECT
0695 32 A2 06                 STA    MBMSEL
0698            *
0698 21 9C 06                 LXI    H,PARAMBLK    ; SET HL=FWA PARAMETER BLK
069B C9                       RET
069C            *
069C            *  PARAMETER BLOCK
069C            *
069C     069C   PARAMBLK:     EQU    $             ;
069C            *
069C 00 00      BLKLEN        DW     0000H         ; BLOCK LENGTH (PAGES)
069E 00         CANALS        DB     00H           ; NUMBER OF FSA CHANNELS
069F 00         ENABLE        DB     00H           ; ENABLE/CNTRL BYTE
06A0 00 00      BEGADR        DW     0000H         ; BEGINNING PAGE NUMBER
06A2 00         MBMSEL        DB     00H           ; BUBBLE BANK
06A3            *
06A3 00 00      BUFADR        DW     0000H         ; USER BUFFER ADDRESS
06A5 00         STATUS        DB     00H           ; RETURN STATUS
06A6            *
06A6                          END

ERRORS THIS ASSEMBLY  0000
```

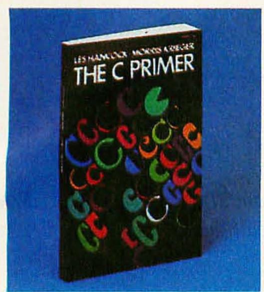
Listing 3: *A BASIC program to exercise/test the BPK 72 bubble-memory kit, software drivers, and operating system linkage. The program, written for Micropolis BASIC, must be modified for use with other BASIC interpreters.*

```
1000 REM ================= BUBBLE MEMORY EXERCISER ==================
1010 REM
1020 REM    REV. A  830413
1030 REM
1040 DIM A$(250), B$(250), D$(250)
1050 Q$=CHAR$(34) :REM  34 = Quote Mark
1060 P=225 :REM Status Port address
1070 OPEN 1 "3:BUBTST" ERROR 1790
1080 REM ---------------------------------------------------------------
1090 PRINT:PRINT: GOSUB 1710: PRINT
1100 C$="":PRINT "Read/ Write/ Read File/ Write File/ Test file/ Quit ";
1110 INPUT C$
1120 IF C$="R" GOTO 1190
1130 IF C$="W" GOTO 1240
1140 IF C$="RF" GOTO 1300
1150 IF C$="WF" GOTO 1390
1160 IF C$="T" GOTO 1480
1170 IF C$="Q" THEN CLOSE 1 : STOP : END
1180 GOTO 1090
1190 REM --------------- READ A RECORD -------------------------------
1200 INPUT "RECORD # ";R
1210 GET 1 RECORD R  A$
1220 PRINT A$
1230 GOTO 1090
1240 REM --------------- WRITE A RECORD ------------------------------
1250 INPUT "RECORD # ";R
1260 INPUT "ENTER DATA TO WRITE ",D$
1270 D$=LEFT$(D$,248)
1280 PUT 1 RECORD R  D$
1290 GOTO 1090
1300 REM --------------- READ A BLOCK OF RECORDS ----------------------
1310 INPUT "BEGINNING RECORD # ";R
1320 INPUT "ENDING RECORD #    ";R9
1330 FOR R=R TO R9
1340 GET 1 RECORD R  A$
1350 PRINT A$
1360 PRINT "---";R
1370 NEXT R
1380 GOTO 1090
1390 REM --------------- WRITE A BLOCK OF RECORDS ---------------------
1400 INPUT "BEGINNING RECORD # ";R
1410 INPUT "ENDING RECORD #    ";R9
1420 INPUT "ENTER TEST DATA",D$
1430 D$=Q$+LEFT$(D$,248)+Q$
1440 FOR R=R TO R9
1450 PUT 1 RECORD R  D$
1460 NEXT R
1470 GOTO 1090
1480 REM --------------- TEST A BLOCK OF RECORDS ----------------------
1490 INPUT "BEGINNING RECORD # ";R
1500 INPUT "ENDING RECORD #    ";R9
```

Listing 3 continued on page 408



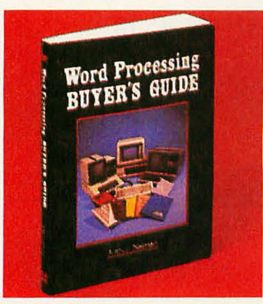
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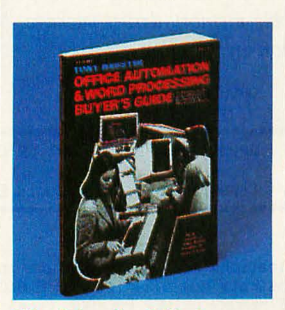
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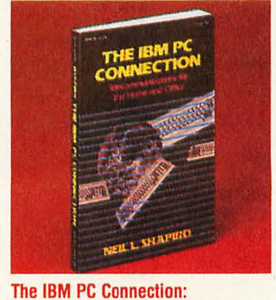
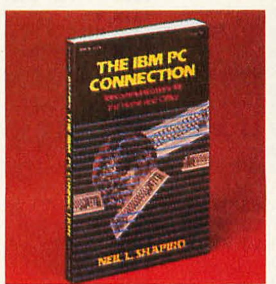


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Listing 3 continued:

```
1510 D$="ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890abcdefghijklmnopqrstuvwxyz"
1520 D$=D$+D$+D$+D$
1530 A$=Q$+D$+Q$
1540 FOR R=R TO R9
1550 PUT 1 RECORD R  A$
1560 S=INP(P) AND 253: IF S<>65 THEN GOSUB 1640
1570 GET 1 RECORD R  B$
1580 S=INP(P) AND 253: IF S<>64 THEN GOSUB 1640
1590 IF B$<>D$ THEN GOSUB 1640
1600 IF R/10 = INT(R/10) THEN PRINT "RECORD #";R;" COMPLETED."
1610 NEXT R
1620 PRINT: PRINT "NUMBER OF ERRORS = ";E
1630 GOTO 1090
1640 REM ---
1650 PRINT "ERROR ENCOUNTERED IN RECORD # ";R
1660 E=E+1
1670 GOSUB 1730: GOSUB 1710
1680 PRINT B$
1690 PRINT
1700 RETURN
1710 REM -------------- DISPLAY STATUS IN HEX -----------------------
1720 S=INP(P) AND 253
1730 S1=INT(S/16)+48
1740 IF S1>57 THEN S1=S1+7
1750 S2=(S AND 15)+48
1760 IF S2>57 THEN S2=S2+7
1770 PRINT "STATUS = ";CHR$(S1);CHR$(S2)
1780 RETURN
1790 REM -------------- ERROR PROCESSOR -----------------------------
1800 PRINT:PRINT ERR$;"      ";
1810 GOSUB 1710
1820 GOTO 1090
1830 END
```

Listing 4: *The CP/M bubble-memory-driver linkage. This program illustrates how the CP/M BIOS can be altered to use the bubble-memory-driver package. Modification specifics are dependent on the CP/M implementation in question.*

```
ADDR B1 B2 B3 E LINE LABEL        OPCD  OPERAND

0000              * *****************************************************************
0000              *                  CP/M BIOS - BUBBLE DRIVER LINKAGE              *
0000              *                                                                 *
0000              *                  Copyright (C) 1983  Louis E. Wheeler           *
0000              * *****************************************************************
0000              *
0000              *
0000              *  The modifications presented here are intended as an example only.
0000              *  They demonstrate how a typical CP/M BIOS can be modified to use
0000              *  the BUBBLE MEMORY DRIVER PACKAGE (separate listing).
0000              *
0000              *  To incorporate these changes, the BIOS jump table must be
0000              *  located, along with free space to store the added code.  Then,
0000              *  the modified BIOS should be installed in the system following
0000              *  the instructions given in the appropriate CP/M manual.
0000              *
0000              *  This listing is divided into two sections: (1)  Patches.
0000              *  (2) Added Code.  All patch addresses shown are for a 32K CP/M
0000              *  configured by Centa for a Micropolis disk system.
0000              *
0000              *
0000              * *****************************************************************
0000              *                            PATCHES                              *
0000              * *****************************************************************
0000              *
0000              *  This section revises the existing BIOS jump table to go to
0000              *  the added code routines listed below.  The actual location of
0000              *  the jump table and address of the patches is dependent on
0000              *  the existing BIOS.  Each system is different.  The ORG's
0000              *  shown in this assembly are for a CP/M configured by Centa Systems
0000              *  for Micropolis disk systems.
0000              *
0000     7500       BIOS          EQU   7500H         ; CP/M BIOS Base Address
0000              *
0000              *
0000                            ORG   BIOS+24       ; Location of Jump Table + 24
7518              *
7518 C3 2B 80                   JMP   BHOME         ; Patch for HOME
751B              *
751B                            ORG   BIOS+36       ; Jump table + 36
7524              *
7524 C3 34 80                   JMP   BSETDMA       ; Patch for SETDMA
7527 C3 5F 80                   JMP   BREAD         ; Patch for READ
752A C3 71 80                   JMP   BWRITE        ; Patch for write
752D              *
752D                            ORG   BIOS+48       ; Jump table + 48
7530              *
7530 C3 3D 80                   JMP   BSECTRAN      ; Patch for SECTRAN
7533              *
7533              *  The following equates taken from existing BIOS jump table.
7533              *
7533     7827       HOME          EQU   BIOS+327H     ; *** Depends on existing BIOS ***
7533     7801       SETDMA        EQU   BIOS+301H     ; *** Depends on existing BIOS ***
7533     7852       READ          EQU   BIOS+352H     ; *** Depends on existing BIOS ***
7533     78FD       WRITE         EQU   BIOS+3FDH     ; *** Depends on existing BIOS ***
7533     77E9       SECTRAN       EQU   BIOS+2E9H     ; *** Depends on existing BIOS ***
```

Listing 4 continued on page 410

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Listing 4 continued:

```
7533            *
7533      7714  GOCPM        EQU   BIOS+214H    ; *** Depends on existing BIOS ***
7533            *
7533                         ORG   GOCPM
7714            *
7714 C3 00 80                JMP   BGOCPM       ; GO INIT BUBBLE MEMORY
7717            *
7717            *  The following changes the number of system disks from 2 to 4.
7717            *  Exactly how this patch is made is dependent on the specific system.
7717            *
7717                         ORG   BIOS+38H     ; *** Depends on existing BIOS ***
7538            *
7538 02                      DB    02H          ; Increase DISK's to 3.
7539 03                      DB    03H          ; Increase DISK's to 4.
753A            *
753A            *  The following changes the disk size parameter in DPBLK2.
753A            *  Note: This change may only be applicable to Micropolis disk systems.
753A            *  The Centa Systems version of the BIOS has two DPBLK's, one each for
753A            *  the two models of Micropolis disk drives (Mod I and Mod II).
753A            *
753A                         ORG   BIOS+0D8H    ; *** Depends on existing BIOS ***
75D8            *
75D8 3C                      DB    3CH          ; Change (DMS) disk size (DPBLK2)
75D9            *                               ; to reflect bubble memory capacity.
75D9            *
75D9            *
75D9            * *****************************************************************
75D9            *                          ADDED CODE                             *
75D9            * *****************************************************************
75D9            *
75D9            *
75D9      0003  NDISKS       EQU   3            ; NUMBER OF DISKS (0,1,2 & BUBBLE)
75D9      0020  SECTRK       EQU   32           ; CP/M 128-BYTE SECTORS/TRACK
75D9      0080  SECSZE       EQU   128          ; CP/M SECTOR SIZE
75D9            *
75D9      7A49  DISKNO       EQU   BIOS+549H    ; *** Depends on existing BIOS ***
75D9      7A4A  TRACK        EQU   BIOS+54AH    ; *** Depends on existing BIOS ***
75D9      7A4D  DMAAD        EQU   BIOS+54DH    ; *** Depends on existing BIOS ***
75D9            *
75D9      0002  SBLKLEN      EQU   0002H        ; BLOCK LENGHT = 2 PAGES = 128 BYTES
75D9      0001  SCANALS      EQU   01H          ; NUMBER OF FSA CHANLS = 2
75D9      0020  SENABLE      EQU   20H          ; ENABLE BYTE = RCD & HI-SPD
75D9      0000  SBEGADR      EQU   0000H        ; BEGIN ADDR = PAGE 0
75D9      0000  SMEMSEL      EQU   00H          ; BUBBLE NUM SELECT = FIRST
75D9            *
75D9            *
75D9            *  The following equates link these modifications to the BUBBLE
75D9            *  MEMORY DRIVER routines.  The addresses shown equate to a jump
75D9            *  table in an EEPROM pointing to the drivers, also located in
75D9            *  EEPROM.  The actual location will depend on the system.
75D9            *
75D9      F018  BMINIT       EQU   0F018H       ; BUBBLE MEMORY INITALIZE
75D9      F01B  BMREAD       EQU   0F01BH       ; BUBBLE MEMORY READ
75D9      F01E  BMWRIT       EQU   0F01EH       ; BUBBLE MEMORY WRITE
75D9            *
75D9            *
75D9            *  The following PARAMETER BLOCK can be ORG'd to any convenient
75D9            *  area in read/write memory.  If the BIOS are not in PROM, the
75D9            *  PARAMETER BLOCK can be located within the BIOS.
75D9            *
75D9                         ORG   BIOS+0E2H    ; *** Depends on existing BIOS ***
75E2            *
75E2      75E2  PARAMBLK     EQU   $            ; BUBBLE MEMORY PARAMETER BLOCK
75E2            *
75E2 00 00      BLKLEN:      DW    0000H        ; BLOCK LENGTH (PAGES)
75E4 00         CANALS:      DB    00H          ; NUMBER OF FSA CHANNELS
75E5 00         ENABLE:      DB    00H          ; ENABLE/CNTRL BYTE
75E6 00 00      BEGADR:      DW    0000H        ; BEGINNING PAGE NUMBER
75E8 00         MBMSEL:      DB    00H          ; BUBBLE BANK
75E9 00 00      BUFADR:      DW    0000H        ; USER BUFFER ADDRESS
75EB 00         STATUS:      DB    00H          ; RETURN STATUS
75EC            *
75EC            * *****************************************************************
75EC            *  The following equates determine where the below patches are
75EC            *  to be stored in the BIOS area of CP/M.  The actual locations
75EC            *  are dependent on the specific BIOS.
75EC            *
75EC      8000  AREA1        EQU   BIOS+0B00H   ; Where to put GOCPM patch.
75EC      0000  AREA2        EQU   0            ; Where to put HOME patch.
75EC      0000  AREA3        EQU   0            ; Where to put SETDMA patch.
75EC      0000  AREA4        EQU   0            ; Where to put SECTRAN patch.
75EC      0000  AREA5        EQU   0            ; Where to put READ patch.
75EC      0000  AREA6        EQU   0            ; Where to put WRITE patch.
75EC            *
75EC            *
75EC            * *****************************************************************
75EC            *  GOCPM - System hardware initialization.
75EC            *
75EC                         ORG   AREA1        ; *** Depends on existing BIOS ***
8000            *
8000 21 02 00   BGOCPM:      LXI   H,SBLKLEN    ; SET BLOCK LENGTH
8003 22 E2 75                SHLD  BLKLEN
8006 3E 01                   MVI   A,SCANALS    ; SET NUMBER FSA CHANNELS
8008 32 E4 75                STA   CANALS
800B 3E 20                   MVI   A,SENABLE    ; SET ENABLE BYTE
800D 32 E5 75                STA   ENABLE
8010 21 00 00                LXI   H,SBEGADR    ; SET BEGINNING PAGE NO.
```

Listing 4 continued on page 412

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Text continued from page 406:

simply loads the boot-loop registers and readies the BMC for operation.

When everything checks out, all that remains is to save the modified Res module.

CP/M Linkage

The modifications required for CP/M are more extensive and complicated than those for MDOS, and the installation isn't as simple. However, the CP/M modification provides complete disk emulation (see listing 4). Programs, including transient commands, as well as data can be stored in bubble memory. It is a real pleasure to enter Stat and get an immediate response without the usual "clank, whirrr" of the floppy disk. The assembler and other programs that require disk access also run much faster and quieter. However, since no changes to the "warm-boot" sequence have been made, a Control-C still boots the CCP (console command processor) and BDOS from floppy disk. There is, of course, no reason why a warm boot or, for that matter, a cold start cannot be made directly from bubble memory if the necessary revisions are made to the boot loader. I have not done so yet, but it appears to be a simple task for the experienced assembly-language programmer.

Explaining the modification to CP/M would be much easier if the CCP or BDOS portions of the operating system were being altered. These two CP/M modules are standard for all CP/M systems. But the BIOS or CBIOS (customized BIOS) module is hardware dependent, and we must modify this module to enable CP/M to communicate with the bubble-memory-driver package.

Altering the CP/M operating system for bubble memory is quite similar to the modification described in "Building a Hard-Disk Interface for an S-100 System, Part 3: Software" in the May 1983 BYTE (page 368). The approach I have taken is slightly different. Instead of creating a new BIOS, listing 4 shows how an existing BIOS can be patched to accomplish the same end. I chose to patch rather than revise because I didn't have a complete source listing for the disk

Listing 4 continued:

```
8013 22 E6 75           SHLD   BEGADR
8016 AF                 XRA    A              ; SET BM BANK SELECT
8017 32 E8 75           STA    MBMSEL
801A 21 E2 75           LXI    H,PARAMBLK     ; FWH PARAMBLK TO HL
801D CD 18 F0           CALL   BMINIT         ; GO INITIALIZE BM
8020 DA 20 80 ERROR:    JC     ERROR          ; HANG OR DO SOMETHING IF ERR
8023             *
8023 3E C3              MVI    A,0C3H         ; *** Restore existing  BIOS code ***
8025 32 00 00           STA    0000           ; *** replaced by JMP instruction
8028 C3 17 77           JMP    GOCPM+3        ; RETURN TU EXISTING BIOS+3
802B             *
802B             *    -> Continue with existing BIOS code.
802B             *
802B             * ****************************************************************
802B             *  HOME - Move to track 00 position of current drive
802B             *
802B                    ORG    $              ; AREA2 ***
802B             *
802B 3A 49 7A BHOME:    LDA    DISKNO         ; GET DISK NUMBER
802E FE 03              CPI    NDISKS         ; CHECK FOR BUBBLE MEMORY
8030 C8                 RZ                    ; RETURN IF BUBBLE (NO ACTION)
8031 C3 27 78           JMP    HOME
8034             *
8034             *    -> Continue with existing BIOS code.
8034             *
8034             * ****************************************************************
8034             *  SELDSK - Select disk given by register C
8034             *
8034             *    -> No modification required.
8034             *
8034             * ****************************************************************
8034             *  SETTRK - Set track given by register C
8034             *
8034             *    -> No modification required unless your BIOS actually
8034             *    -> positions the disk head to the selected track.  If this
8034             *    -> is the case, perform the test shown for HOME.
8034             *
8034             * ****************************************************************
8034             *  SETSEC - Set sector given by register C
8034             *
8034             *    -> No modification required.
8034             *
8034             * ****************************************************************
8034             *  SETDMA - Set DMA address given by registers B and C
8034             *
8034                    ORG    $              ; AREA3 ***
8034             *
8034 69       BSETDMA:  MOV    L,C            ; LOW ORDER ADDRESS
8035 60                 MOV    H,B            ; HIGH ORDER ADDRESS
8036 22 4D 7A           SHLD   DMAAD          ; SAVE THE ADDRESS
8039 22 E9 75           SHLD   BUFADR         ; FUR BUBBLE TOO.
803C             *
803C             *    -> Include any additional code your system may require,
803C             *    -> probably none.
803C             *
803C C9                 RET                   ; No add'l code req'd for Micropolis.
803D             *
803D             * ****************************************************************
803D             *  SECTRAN - Translate the sector number given by B and C
803D             *
803D                    ORG    $              ; AREA4 ***
803D             *
803D 3A 49 7A BSECTRAN: LDA    DISKNO         ; GET DISK NUMBER
8040 FE 03              CPI    NDISKS         ; CHECK FUR BUBBLE MEMURY
8042 C2 E9 77           JNZ    SECTRAN        ; IF NOT, GO DO DISK.
8045             *
8045 C5                 PUSH   B              ; SAVE SECTUR
8046 11 00 00           LXI    D,0000H        ; CLEAR DE
8049 2A 4A 7A           LHLD   TRACK          ; TRACK # TO HL
804C 62                 MOV    H,D            ; CLEAR H, L=TRACK
804D EB                 XCHG
804E 3E 20              MVI    A,SECTRK       ; GET SECTURS PER TRACK
8050 87                 ADD    A              ; MULTIPLY BY 2
8051 19       BMPY:     DAD    D              ; BEG TRK ADR =
8052 3D                 DCR    A              ; TRK * SECTRK * 2
8053 C2 51 80           JNZ    BMPY           ; LOOP TU MULTIPLY.
8056 79                 MOV    A,C            ; GET SECTUR NUMBER
8057 87                 ADD    A              ; MPY BY 2
8058 4F                 MOV    C,A            ; PUT IT BACK
8059 09                 DAD    B              ; ADD IT TU BEG TRK ADR
805A 22 E6 75           SHLD   BEGADR         ; SAVE IN BEGADR.
805D E1                 POP    H              ; PUT SECTUR IN HL
805E C9                 RET                   ; BUBBLE EXIT.
805F             *
805F             * ****************************************************************
805F             *  READ - READ SELECTED CP/M SECTUR
805F             *
805F                    ORG    $              ; AREA5 ***
805F             *
805F 3A 49 7A BREAD:    LDA    DISKNU         ; GET DISK NUMBER
8062 FE 03              CPI    NDISKS         ; CHECK FUR BUBBLE
8064 C2 52 78           JNZ    READ           ; NO, GO READ DISK
8067             *
8067 F3                 DI                    ; KILL INTERRUPTS.
8068 21 E2 75           LXI    H,PARAMBLK     ; FWH PARAMBLK TU HL
806B CD 1B F0           CALL   BMREAD         ; GO READ BUBBLE DATA
806E C3 80 80           JMP    BRWEX          ; GO TAKE COMMUN EXIT.
```

Listing 4 continued on page 414

Listing 4 continued:

```
8071             *
8071             *
8071             * ************************************************************************
8071             *  WRITE - WRITE SELECTED CP/M SECTOR
8071             *
8071                                ORG     $               ; AREA6 ***
8071             *
8071 3A 49 7A    BWRITE:            LDA     DISKNU          ; GET DISK NUMBER
8074 FE 03                          CPI     NDISKS          ; CHECK FOR BUBBLE
8076 C2 FD 78                       JNZ     WRITE           ; NO, GO WRITE DISK
8079             *
8079 F3                             DI                      ; KILL INTERRUPTS.
807A 21 E2 75                       LXI     H,PARAMBLK      ; FWA PARAMBLK TO HL
807D CD 1E F0                       CALL    BMWRIT          ; GO WRITE BUBBLE DATA
8080             *
8080 FB          BRWEX:             EI                      ; OMIT THIS INSTRUCTION
8081             *                                          ; IF YOUR SYSTEM DOES
8081             *                                          ; NOT USE INTERRUPTS.
8081 3E 00                          MVI     A,0             ; CLEAR A-REG
8083 D0                             RNC                     ; NO PROBLEM EXIT.
8084 3C                             INR     A
8085 C9                             RET                     ; ERROR EXIT.
8086             *
8086             *

 ERRORS THIS ASSEMBLY  0000
```

portion of my BIOS, which was written by Centa Systems for Micropolis.

If you are fortunate enough to have a complete listing of your BIOS, or you are using a Micropolis disk system and CP/M with BIOS written by Centa Systems, the modification should not be too difficult. If not, you will probably have to unleash your disassembler to uncover a few hidden locations. You need to know the location of the current selected disk number, the selected track, and the DMA (direct memory access) address (user buffer address). You must also find out where and how your BIOS determines whether a selected disk number is legal or not and fix it so that the number that you select for the bubble memory is acceptable.

Another thing you will need is an unused area large enough to hold the added code. About 130 locations will be required, but they need not be contiguous. The source code shown in listing 4 is designed to be segmented and scattered around memory wherever space is available. The version of CP/M that I am using is quite tight on space. Therefore, as a temporary measure for testing, I assembled the added code to start at hexadecimal location 8000, which is above my 32K-byte CP/M. This lets me use the DDT (dynamic debugging tool) to load the added code and make the rest of the patches by hand. In the future, I plan to revise the "stream I/O handler" so that the peripheral drivers I have stored in EEPROM are used instead of the I/O routines located within the BIOS module. This will free up sufficient storage for the bubble-memory-driver linkage. The listing is intended primarily as an example. Exactly how you incorporate the added code and changes depends on the specifics of your system BIOS.

Installing a new operating system is covered in the CP/M manual and also in the May 1983 BYTE article (see figure 6 on page 378). The method I used differs only in that I used DDT to make the patches to the BIOS jump table and the jump instruction patched at the beginning of GOCPM.

After completing the installation, a BASIC program like the one shown in listing 3 can be used for testing. Some modifications to the disk instructions (OPEN, CLOSE, GET, PUT) and the INP instruction probably will be required; otherwise, the program should function as written.

Since the CP/M alteration is a true disk emulation complete with directory, initialization of the bubble memory is required before it can be used. My CP/M system came with a program called VOLPREP.COM; however, it did not work with the bubble memory. Fortunately, an assembly-language file (VOLPREP.ASM) was provided, and I quickly discovered that the program directly accessed the disk drivers rather than the BIOS jump table. Consequently, it was not getting to the bubble-memory drivers. A simple change in the address table in the beginning of the VOLPREP program plus a few other minor changes were all that was required to make it work.

I am very pleased with the performance of the bubble-memory project; with it, I no longer fear the flickering lights. I used it to write this article, which was much too long to fit in my system's RAM. Yet with the bubble-memory addition, my text editor performed as though it had adequate space.

With even larger-capacity bubble-memory chips on the way (Intel recently announced a 4-megabit version), I would not be surprised to see bubble memories beginning to replace hard disks in small or portable computer systems. Using the newer chips, it should be relatively easy to put 4 megabytes of reliable bubble storage inside the cabinet of an S-100 computer. I believe that bubble memories will replace floppy disks in some systems, particularly in the portables.■

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Calculating Overhead Costs by Computer

A simple, foolproof arithmetic procedure determines the distribution of indirect costs quickly and accurately

by G. Truman Hunter

This article demonstrates how an accounting application that can be used by all types of businesses eases the distribution of indirect, or overhead, costs. Specifically, it shows how to calculate those costs using an arithmetic procedure that provides information that is more accurate than that obtainable using approximation procedures. In addition, the method described here does not require the long, tedious work the approximation approach demands. The accounting procedure can be used on a large computer as well as a small one, and it can also provide results on a hand-held calculator.

An Accounting Problem

The procedure solves a common accounting problem by permitting a computer user to calculate costs that are transferred among departments of a company. Determining such costs is known as indirect cost accounting, overhead cost distribution, *burden* distribution, or burden cost accounting. Cost accountants have been calculating these transfer costs for decades, relying on estimates and approximation procedures to minimize the cost of the calculations in time, money, and effort.

In fact, it's well known that solving the problem of calculating the cost of reciprocal transfers among departments requires the solution of a set of simultaneous equations. Before computers were widely available, these results took many hours to calculate by hand. And because the starting point for the procedure was often a set of estimates of dubious accuracy, many people believed that precise solutions were unobtainable and therefore unimportant. Consequently, emphasis was on speedy approximations rather than exact answers.

Cost-accounting textbooks took the same approach, telling their readers that if more than four or five departments were involved, solving simultaneous equations would not be practical. Instead, they proposed using such methods as the Christmas Tree or the Waterfall approach. Their names come from the geometry of the solution, where a decreasing number of departments provides a triangular picture of data as costs flow from one level to the next. The first department examined has its costs distributed to all other departments, and no costs are returned to it. That department is then no longer involved in the calculations. The next department then has its costs distributed, with none returned to it, and the procedure thus continues. Data on the less important departments is collected first, and the final product departments are done last; the product departments cannot distribute charges among themselves.

This process did not tell the user where the indirect costs, or burdens, originated. Since the source was not known, there was no way to attack the problem of reducing specific distribution costs. Moreover, no trail showed the actual transfer of dollars from each department to every other department under this old scheme.

With the simultaneous-equation solution, on the other hand, an exact number of dollars for every distribution factor is known. This method easily leads to reductions in overhead costs.

History of a Faster Solution

I was first introduced to the problem of indirect cost accounting in 1951, when a steel company asked IBM to tackle such a problem. It was taking the firm about 300 man-hours to calculate those costs by hand.

After I studied the problem and read an accounting handbook, I found a practical solution: the Gauss-Seidel iterative procedure. This procedure provides easy error detection and is simple, foolproof, and fairly fast. The nature of its equations and values guarantees a solution.

The steel-company case required a set of 51 equations for 51 departments and a possible 51 × 50 transfers. Only about 600 of 2550 possible transfers actually occurred, however. This ratio—about 1:4—of the number of actual to theoretical transfer relations has held for several similar business applications.

Once the procedure was worked out, the calculations took only 35 minutes on an IBM card-programmed calculator. The calculation procedure is iterative: each intermediate set of answers gets closer to the final set. When no further changes take place, the solution has been reached.

This procedure actually converged at a rate of almost one decimal column for each iteration, so that figures involving values to $999,999 can converge to the final answer in about six

$$
\begin{aligned}
& && F(B,A)\times T(B) + F(C,A)\times T(C) + F(D,A)\times T(D) + DC(A) &= T(A)\\
F(A,B)\times T(A) + & && F(C,B)\times T(C) + F(D,B)\times T(D) + DC(B) &= T(B)\\
F(A,C)\times T(A) + F(B,C)\times T(B) + & && + F(D,C)\times T(D) + DC(C) &= T(C)\\
F(A,D)\times T(A) + F(B,D)\times T(B) + F(C,D)\times T(C) + & && + DC(D) &= T(D)
\end{aligned}
$$

Figure 1: *Equation layout for 4-department indirect cost calculations.*

or seven iterations. In other words, the accuracy of the estimates of the final answers increases about one decimal place per iteration.

When I originally tried to convince several accountants to try this procedure, I heard many excuses as to why they thought it had no value. After one accountant had told me repeatedly that his starting data was approximate and that he therefore didn't need the precision I could provide, I told him that this procedure could give him any level of inaccuracy he desired. Needless to say, he didn't appreciate sarcasm any more than the truth.

In 1953, this procedure was used on an IBM 701 computer to solve an indirect-cost-accounting problem for 156 departments of a large New York City bank. Calculating and printing the answers took about 10 minutes, considerably less than the 1000 man-hours required for hand-calculation procedures. When the procedure was followed for a 91-department bank, an IBM 650 calculator did the job in 7.5 minutes, replacing a 300 man-hour hand calculation. Similar savings were realized for a pharmaceutical company's 45-department distribution. A state hospital then used the procedure to reduce a several-month task to a 4-day job on punched-card machines. A lot of card handling was required because the institution had no computer.

A Sample Problem

The current availability of microcomputer-spreadsheet programs makes the solution even easier. Here's a sample procedure for analyzing costs for four departments. It is not a real case and takes more iterations to solve than an actual problem would, but it uses the procedure that actual cases follow.

First, this simple four-department distribution demonstrates how to set up the necessary equations and use the procedure to obtain a solution. Then the sample is worked out using the usual spreadsheet notation of rows and columns.

The total cost of each department is made up of the charges transferred to it from all other departments, plus its own direct charges. The total cost for department A is best stated with this equation:

$$\text{Cost (B to A)} + \text{Cost (C to A)} + \text{Cost (D to A)} + \text{Direct cost (A)} = \text{Total cost (A)}$$

To simplify subsequent calculations, the equation can be expressed as:

$$F(B,A)\times T(B) + F(C,A)\times T(C) + F(D,A)\times T(D) + DC(A) = T(A)$$

where T represents the total cost of a department named by the letter in the parentheses following it, F represents the distribution factor between two departments (the first department mentioned is the source of the costs and the second is the receiver), and DC represents the direct charges of a specific department.

The equations in figure 1 are used to calculate indirect costs for a four-department distribution. Because no department distributes costs to itself, a gap is left in each line. Note the symmetry to the equations; they are set up to fit nicely into a spreadsheet arrangement of rows and columns, organized by departments. The calculations along a row correspond to the costs absorbed by a particular department, and those down a column correspond to transfer of costs from one department to others.

After the equations are set up, the factors for making distributions between departments are needed. Calculation of the distribution factors is done separately and is not part of the distribution-calculation procedure. The information for developing the factors for a company should be available from the firm's accounting department and, indeed, the factors themselves may already be available.

One way a department might measure its distribution of the costs for services, for example, is based on the number of persons in each department. If a department has one percent of the company's personnel, for instance, and it is assumed that all personnel share the use of the cafeteria, then one percent of cafeteria expenses would be distributed to that department. Figures then would be calculated in a similar manner for other departments. Telephone expenses, however, might best be distributed based on the number of phones rather than people in each department, although long-distance costs can be charged directly to the department that made them. The distribution factors can also be based on relative amounts of floor space or on any items that can (and must) be quantified. Each factor is a number between zero and one inclusive.

Once all the factors are known, they can be substituted in the equations. For this example, a set of factors and initial expense values is used. Note that the gaps have been filled with a zero factor, which can ease some computer procedures.

$$.00\times T(A) + .10\times T(B) + .15\times T(C) + .15\times T(D) + 8000 = T(A)$$

$$.15\times T(A) + .00\times T(B) + .20\times T(C) + .10\times T(D) + 7000 = T(B)$$

$$.00\times T(A) + .10\times T(B) + .00\times T(C) + .30\times T(D) + 9000 = T(C)$$

$$.15\times T(A) + .15\times T(B) + .10\times T(C) + .00\times T(D) + 12000 = T(D)$$

Now the only unknown quantities in these equations are the depart-

ment's total expenses. The paradox, however, is that you can't calculate the total expenses unless you already know them. Here the powerful iterative procedure is useful.

For the first equation, assume that the total expenses are the direct expenses. Then the first equation becomes:

$$0 + .10 \times 7000 + .15 \times 9000 + .15 \times 12000 + 8000 = T(A)$$

$$0 + 700 + 1350 + 1800 + 8000 = T(A) = 11850$$

The estimate for total expenses of department A gets more accurate, going from a value of 8000 to 11,850.

Using that new value in the second equation and other values assumed to represent total expenses provides a new figure for T(B) of 11,775, which is considerably better than the first estimate of 7000. Similar substitutions and calculations that cycle through the four departments lead to the final answers. When no further changes occur, the final totals are

$$T(A) = 14{,}455$$
$$T(B) = 14{,}108$$
$$T(C) = 15{,}769$$
$$T(D) = 17{,}861$$

Now that the total costs for each department are known, we can calculate the net, or true, final cost by subtracting the amounts distributed from each department to others. They can be found with the same general equations, because the amount going to a department has to come from some other department. In this example, department A distributes $2168 to department B and $2168 to department D, leaving a net cost of $10,118. The net costs for the other departments are calculated similarly.

When the distributions both to and from all departments are calculated, the sum of the costs must equal the initial costs of the four departments, because we can neither gain nor lose any dollars. Because the original sum was $36,000, the sum of the net costs must also be $36,000. (Verifying that these sums match is a way to check the accuracy of the calculations and the procedures.)

Spreadsheet Procedures

The setup for this sample data using a typical electronic spreadsheet procedure is shown in table 1. Row 3 has spaces for the total expenses of each department and the sum of all departments. Rows 6 through 9 are designed to hold the calculations for the distributed amounts to each department as well as each department's direct (initial) charges and total costs.

Row 11 will hold the net expenses for each department and the sum for all the departments. Net amounts are calculated by subtracting the distributed amounts in each column from the total in row 3.

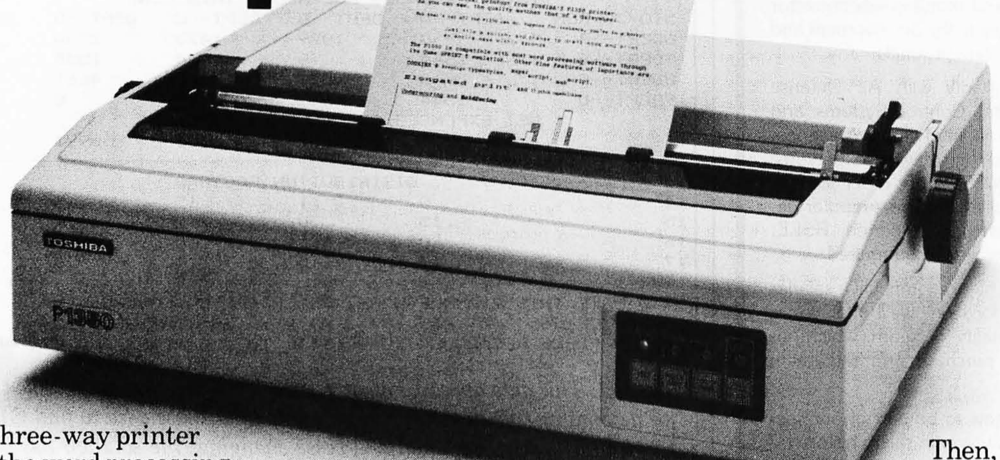
Because no department can distribute more than 100 percent of its total expense, net expense can never be negative. The net expense can be a few cents or a dollar under, however, as a result of accumulated rounded-off values in the calculation procedures. Rows 14 through 17 contain the factors for calculating the costs to be transferred between each pair of departments.

The usual spreadsheet program is set up to detect the type of circular relationships that exist between the department totals. It prevents the use of an analysis that incorporates such relationships by substituting the values comprising them with the word "error," thus indicating errors. Therefore, to avoid the problem of having the screen filled with error signs, the row of totals—B3 through E3—has the total for each department set to zero. Once this precaution has been taken, you can manipulate the figures on the terminal screen, but you must be sure that no circular relationships are stated when you store your data, or you will get error signals when you reload the sheet.

Before you can begin solving a particular problem, the row of totals must be copied from the column of totals at the right (G6 through G9) to row 3 (B3 through E3). Table 2 shows the resulting data at this point. The sum of the net expenses does not equal the total of the initial expenses



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	A	B	C	D	E	F	G
1		INDIRECT COST DISTRIBUTION----ACCOUNTING PROCEDURE					
2	==========						
3		0	0	0	0	0	
4		TOTAL EXPENSES ARE ABOVE THIS LINE					
5	TO///FROM	DEPT--A	DEPT--B	DEPT--C	DEPT--D	INITIAL	TOTAL
6	DEPT--A	0	0	0	0	8000	8000
7	DEPT--B	0	0	0	0	7000	7000
8	DEPT--C	0	0	0	0	9000	9000
9	DEPT--D	0	0	0	0	12000	12000
10		NET EXPENSES ARE BELOW THIS LINE				36000	36000
11		0	0	0	0	0	
12	----------						
13			DISTRIBUTION FACTORS				
14		0	.1	.15	.15		
15		.15	0	.2	.1		
16		0	.1	0	.3		
17		.15	.15	.1	0		
18	==========						
19	TO MAKE THIS EXAMPLE WORK, ENTER THE FOLLOWING:						
20	AT B3, +G6	AT C3, +G7	AT D3, +G8	AT E3, +G9			
21	THEN FORCE RECALCULATIONS UNTIL TOTALS AT F3 AND G10 ARE EQUAL.						

Table 1: *The data for analysis for a hypothetical four-department company is set up here as it would be for use with an electronic spreadsheet program. Row 3 provides spaces for the total expenses of each department, and row 11 will display their net expenses.*

	A	B	C	D	E	F	G
1		INDIRECT COST DISTRIBUTION----ACCOUNTING PROCEDURE					
2	==========						
3		10293	10287	9820	15535	45935	
4		TOTAL EXPENSES ARE ABOVE THIS LINE					
5	TO///FROM	DEPT--A	DEPT--B	DEPT--C	DEPT--D	INITIAL	TOTAL
6	DEPT--A	0	1029	1473	2330	8000	12832
7	DEPT--B	1544	0	1964	1554	7000	12061
8	DEPT--C	0	1029	0	4661	9000	14689
9	DEPT--D	1544	1543	982	0	12000	16069
10		NET EXPENSES ARE BELOW THIS LINE				36000	55652
11		7205	6687	5401	6991	26283	
12	----------						
13			DISTRIBUTION FACTORS				
14		0	.1	.15	.15		
15		.15	0	.2	.1		
16		0	.1	0	.3		
17		.15	.15	.1	0		
18	==========						
19	TO MAKE THIS EXAMPLE WORK, ENTER THE FOLLOWING:						
20	AT B3, +G6	AT C3, +G7	AT D3, +G8	AT E3, +G9			
21	THEN FORCE RECALCULATIONS UNTIL TOTALS AT F3 AND G10 ARE EQUAL.						

Table 2: *This data appeared during the calculation procedure. Note that the calculations for determining F3 are always one cycle behind those used to find G10. When the values for the two spaces are equal and cease changing, the solution has been reached.*

	A	B	C	D	E	F	G
1		INDIRECT COST DISTRIBUTION----ACCOUNTING PROCEDURE					
2	==========						
3		14455	14108	15769	17861	62194	
4		TOTAL EXPENSES ARE ABOVE THIS LINE					
5	TO///FROM	DEPT--A	DEPT--B	DEPT--C	DEPT--D	INITIAL	TOTAL
6	DEPT--A	0	1411	2365	2679	8000	14455
7	DEPT--B	2168	0	3154	1786	7000	14108
8	DEPT--C	0	1411	0	5358	9000	15769
9	DEPT--D	2168	2116	1577	0	12000	17861
10		NET EXPENSES ARE BELOW THIS LINE				36000	62194
11		10119	9170	8673	8038	36000	
12	----------						
13			DISTRIBUTION FACTORS				
14		0	.1	.15	.15		
15		.15	0	.2	.1		
16		0	.1	0	.3		
17		.15	.15	.1	0		
18	==========						
19	TO MAKE THIS EXAMPLE WORK, ENTER THE FOLLOWING:						
20	AT B3, +G6	AT C3, +G7	AT D3, +G8	AT E3, +G9			
21	THEN FORCE RECALCULATIONS UNTIL TOTALS AT F3 AND G10 ARE EQUAL.						

Table 3: *The final results of the four-department analysis. The totals in G6 through G10 correspond respectively to those in B3 through F3.*

at this time because of the lag in the computation procedure. At the end of the several iterations, however, the total net expenses and total initial expenses will be the same.

The total of all departments in F3 is always one cycle behind the total in G10. Both totals increase as each cycle is performed. Eventually, when the two totals agree and stop increasing, the solution is reached. This example takes 11 iterations to obtain a solution. To carry results to the nearest penny takes 21 iterations; the results, however, are not worth the extra effort.

The problem is now ready for the iteration procedure, which is signaled via the Recalculate key of the system that will perform the calculations. Each time the key is touched, one complete iteration takes place.

Remember that all totals must increase with each calculation. Any decrease indicates an error in values, calculations, or formulas. Table 3 presents the final result. It contains all the factors, all the initial expenses, all the dollars related to each factor, and all the dollars transferred in and out of every department. Now the total expenses of each department can be analyzed to determine what can be done to reduce expenses.

Modifying the Data

After reviewing the results of a set of calculations, you might want to change one or several factors. It is possible to make such changes and then use the Recalculate key to obtain new results. In this case, some amounts will decrease to the new values (contrary to what was said above). However, changes must keep going in the same direction and not oscillate up and down. And because the calculations are easy to make, you can also go back to the beginning with a new set of figures and complete the whole procedure again.

Using BASIC or APL

A similar program can be written to do the same calculations, loop back, and repeat them until the totals do not change. I have written such programs in BASIC and APL.

Listing 1 contains a BASIC program for the sample problem. It will print all intermediate values to the screen and then give final answers in a format similar to that of table 3.

To bypass the printing of intermediate totals, you can delete the PRINT statements in lines 390 and 480. You can also expand with remarks to make it more understandable. Or you can shorten it by putting multiple statements on a line; however, this makes it less understandable.

To include more departments, more data statements must be added and the dimension statements (lines 10–110) must be enlarged to cover the maximum number of departments. The output printing statements must also be changed to accommodate such an increase.

If 100 departments were used, for instance, 10,000 spaces would have to be allocated for the factors and 10,000 for the distributed amounts. At a rate of 2 bytes per space, this analysis would require at least 40,000 bytes of storage. Again, this requirement could be reduced significantly by limiting storage to only the actual factors needed and giving up the symmetry of the tables. Note, however, that large values could require double-precision calculations and a corresponding increase in storage requirements.

In APL, the procedure is even simpler, since the final result to the equations can be found in just one step. You get the inverse of the factor table using the quad-divide function and then multiply the inverse by the initial expense vector. Then you print out the appropriate items of initial, final, net costs, and transferred amounts using appropriate array functions. Mathematicians and APLers will love this trivial procedure.

Hand or Desk Calculator Procedure

With a hand or desk calculator and a large piece of paper, you simply simulate the procedure done by a computer by starting with table 1. Use a soft pencil to write down the distribution amounts and the department total (column G), then replace

Listing 1: *A BASIC program for determining how indirect costs are distributed among the four departments of a hypothetical company.*

```
10 REM program for reciprocal cost distribution among four departments.
20 N=4
30 DATA 0,.1,.15,.15
40 DATA .15,0,.2,.1
50 DATA 0,.1,0,.3
60 DATA .15,.15,.1,0
70 DATA 8000,7000,9000,12000
80 DIM I(4)
90 DIM M(4)
100 DIM T(4)
110 DIM P(4,4)
120 REM set up factor table from data
130 FOR R=1 TO N
140 FOR C=1 TO N
150 READ V
160 LET P(R,C)=V
170 NEXT C
180 NEXT R
190 REM set up initial expense table from data
200 FOR Z=1 TO N
210 READ I(Z)
220 NEXT Z
230 REM set up temporary total expense table
240 FOR Z=1 TO N
250 LET M(Z)=I(Z)
260 NEXT Z
270 REM set up total expense table
280 FOR Z=1 TO N
290 LET T(Z)=I(Z)
300 NEXT Z
310 REM begin calculation iteration
320 FOR R=1 TO N
330 LET G=0
340 FOR C=1 TO N
350 LET D=M(C)*P(R,C)
360 LET G=G+D
370 NEXT C
380 LET M(R)=G+I(R)
390 PRINT R,M(R)
400 NEXT R
410 REM calculate old and new total expenses
420 LET E=0
430 LET F=0
440 FOR Z=1 TO N
450 LET E=E+M(Z)
460 LET F=F+T(Z)
470 NEXT Z
480 PRINT E,F,E-F
490 REM save "new" totals as "old" totals for next iteration
500 FOR Z=1 TO N
510 LET T(Z)=M(Z)
520 NEXT Z
530 REM test for completion of iteration cycles
540 IF (E-F)>=1 THEN 320
550 FOR C=1 TO N
560 LET N(C)=T(C)
570 FOR R=1 TO N
580 LET N(C)=N(C)-T(C)*P(R,C)
590 NEXT R
600 NEXT C
610 FOR Z=1 TO N
620 PRINT INT(I(Z)),INT(T(Z)),INT(N(Z))
630 NEXT Z
640 PRINT "FINISHED"
650 REM print results
660 PRINT "TOTAL EXPENSES ARE;"
670 FOR Z=1 TO N
680 PRINT INT(T(Z)),
690 NEXT Z
700 PRINT " "
710 PRINT
720 PRINT"DISTRIBUTION AMOUNTS ARE:                    INITIAL
 TOTAL"
730 FOR R=1 TO N
740 FOR C=1 TO N
750 PRINT INT(P(R,C)*T(C)),
760 NEXT C
770 PRINT INT(I(R)),INT(T(R))
780 NEXT R
790 PRINT "NET EXPENSES ARE:"
800 LET Q=0
810 FOR C= 1 TO N
820 LET Q=Q+N(C)
830 PRINT INT(N(C)),
840 NEXT C
850 PRINT INT(Q)
860 END
```

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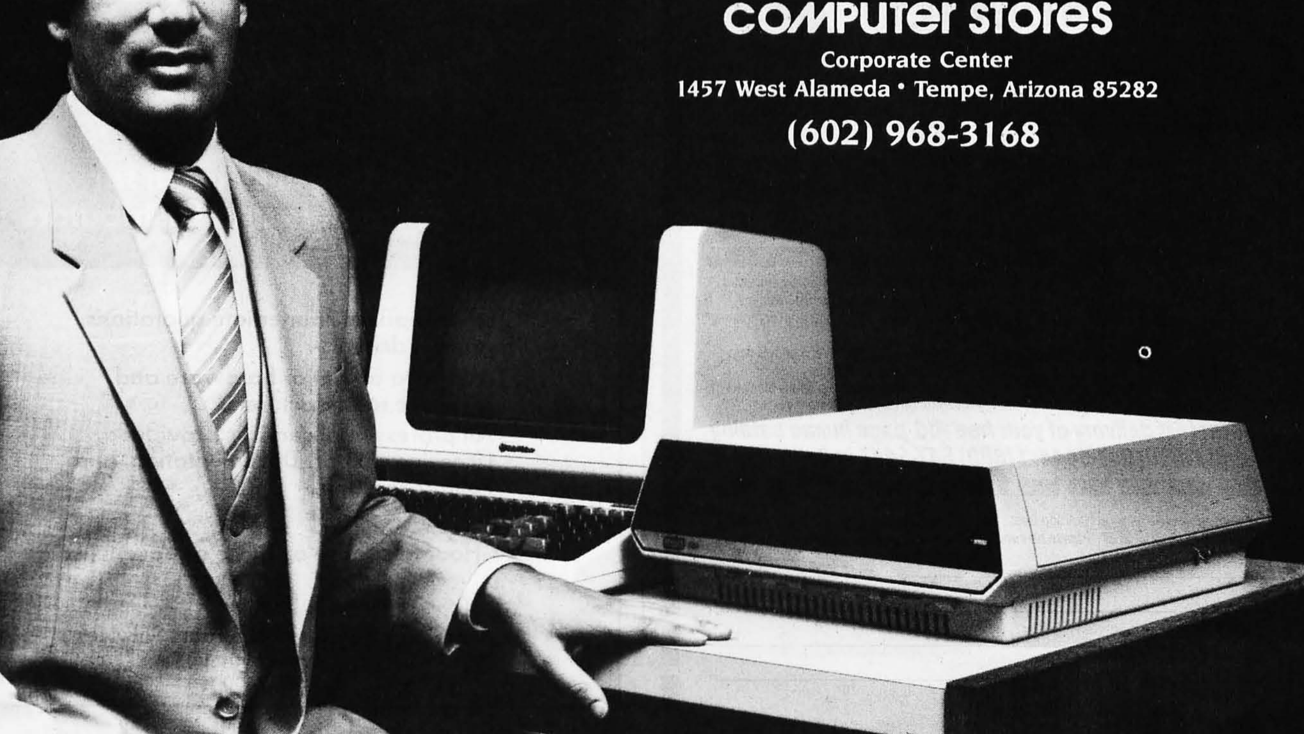
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them when better figures are calculated. The totals are also copied to the top of each column (in row 3) to make it easier to find the pair of numbers involved in each calculation of distribution amount.

Computer Capacity Required

From a practical standpoint, the size of the problem that can be solved using the procedure outlined here depends on the maximum number of columns the spreadsheet program can handle and/or the computer's total storage capacity. For example, if you use an electronic spreadsheet program or a program that stores the full table of distributed amounts and the full table of factors, you will need *much more* storage than if you use only the required nonzero elements.

Because in actual cases about 75 percent of the factors equal zero, you can rearrange and condense the data layout if you're willing to give up the convenience of having all the items line up neatly in their own rows and columns by department. For example, in the 91-department bank case, only 620 factors of the possible 8281 (91 × 91) existed. Thus only 7.5 percent of the possible number of transfers occurred.

The bank's problem was analyzed using DOS 2.0 and Lotus's 1-2-3 in a 327,680-byte IBM Personal Computer (PC). Initially 211,340 bytes were free. Data on the 91 departments would not fit in this space, however, and I estimate that the task would have taken an additional 64K bytes, or a total of 280K bytes, of problem space.

Compare these requirements to those for completing the same job in BASIC, coding only the nonzero factors. That approach required only 11,500 bytes of space for data, program, and stored initial, final, and net expenses. And even with full table space stored, the problem might still have fit into the available 61K bytes of free space in an IBM PC. It took only eight iterations to arrive at the solution—a total-expense figure of over $20 million. That figure is accurate to the nearest dollar. In other words, accuracy improved at a rate of just one iteration per column. And coding for only the nonzero factors speeded program execution.

Conclusion

The data for determining indirect-cost distribution throughout a company can be found in the firm's accounting records. The arithmetical procedure is simple, and the report forms can be custom formatted to suit various user needs. Current accounting books still ignore the use of small computers for business calculations. The availability of small computers and spreadsheet software eases this standard accounting task and provides far more information than has been available under previous approximation methods.■

G. Truman Hunter (31 Overlook Dr., Greenwich, CT 06830) holds a Ph.D. in experimental nuclear physics from the University of Wisconsin and an honorary doctor of science degree from the University of Tampa. He retired from IBM in 1975, at which time he held the position of Manager of APL in the Systems Development Division. Since his retirement he has had more time for Scouting and has taught courses on the use of the IBM PC and other systems.

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Bullet-Proof Pascal Input

This valid-number program holds data-input errors at bay

by David F. Hinnant and Michael B. Smith

One of the major problems with Pascal as implemented on microcomputers and some large mainframes is that data-input errors in running programs can often have catastrophic results. Not only can the program terminate abnormally, but on many microcomputers the entire operating system is often forced to reinitialize; data can be lost or corrupted when disk files are not properly closed or buffers are not flushed before program termination.

When reading in *character* input there is no problem; a character variable can hold practically any key combination available on the terminal keyboard. The data-input error problem surfaces when data of an *unexpected* type is entered. This is most likely to happen when the *running* program is expecting a number but finds an alphabetic character in its input stream. On most UCSD Pascal systems, a message of the form

```
IO error: bad input format
S# 1, P# 1, I# 10
Type <space> to continue
```

informs the user of such an error, and the operating system must then be reinitialized.

Reasonably, then, you would like to input numbers as character strings because the possibility of input errors is remote—but you cannot do arithmetic with strings. Fortunately, Pascal provides a relatively simple way of circumventing this dilemma by providing: (1) a capability to input data as an alphanumeric character string, and (2) the ORD( ) function, which lets the input character string be used to construct a valid number.

The ORD( ) function returns the integer decimal ASCII (American National Standard Code for Information Interchange) code of the character argument passed to it. Because the ASCII values of the numeric characters are in continuous ascending order (see table 1), each character of the input string can be easily tested to see if its ordinal value minus the ordinal value of the first ordered numeric character (0) is a valid counting number (0 through 9). If it is, then the input character is a valid digit. The central algorithm of listing 1 is really quite simple.

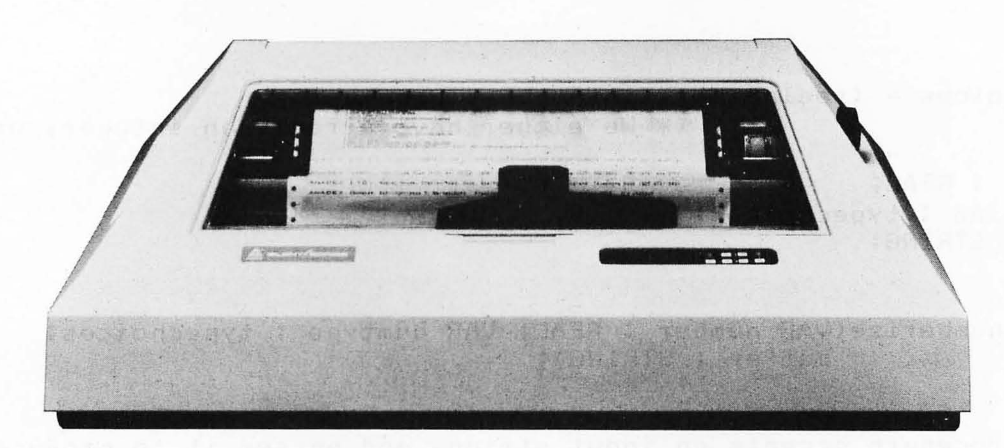
```
str.len := Length(buffer);
position := 1;
number := 0.0;
WHILE (buffer[position] IN ['0'..'9'] AND (position
   <= str.len)
DO BEGIN
   number := number * 10 + ORD(buffer[position])
      - ORD('0');
   position := position + 1;
END;
```

Character (decimal)	ORD(character) (decimal ASCII integer code)	ORD(character)—ORD('0') (integer value)
0	48	0
1	49	1
2	50	2
3	51	3
4	52	4
5	53	5
6	54	6
7	55	7
8	56	8
9	57	9

Table 1: *The ascending values of the decimal ASCII integer codes correspond to the ascending decimal character integers. By subtracting ORD ('0'), which is decimal 48, from the decimal ASCII integer of the input character, the result must fall in the 0–9 range if the input character is to be considered valid.*

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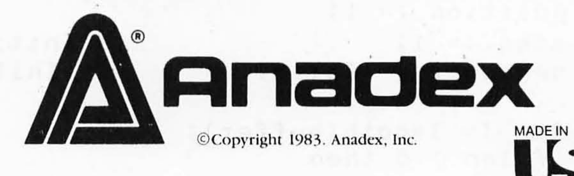
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Listing 1: *The numbertest program verifies that input characters are valid numbers.*

```
(*$r-*)          (* Turn range checking off since we know what we're doing.  *)
PROGRAM numbertest(INPUT, OUTPUT);

  (*
                                  David F. Hinnant
                                  Michael B. Smith
                                     5-Jan-83
  *)


  TYPE
    typechoices = (realnumber, intnumber, nonumber);
                          (* We either have a real, an integer, or garbage *)
  VAR
    result : REAL;
    inputKind : typechoices;
    buff : STRING;


PROCEDURE numberize(VAR number : REAL; VAR numtype : typechoices;
                    buffer : STRING);

  (*
    This procedure accepts an input string, and parses it to produce a
    number.  The number can be either a real or an integer.  The returned
    boolean variable 'input' contains the type of the number.  If the input
    string contains doesn't contain a decimal point, it is assumed to be an
    integer.  The variable 'buffer' contains the input string. The variable
    'number' contains the valid parsed number, if any.
  *)

  CONST
    radix = 10;          (* We are working with base 10 numbers hopefully *)
    decimal='.';

  VAR
    sign, power, position, len, scale : INTEGER;
    negpower : BOOLEAN;
    expset, opset : SET OF CHAR;

  BEGIN
    expset := ['e','E'];          (* valid identifiers for scientific notation *)
    opset := ['+','-'];                                (* valid sign operators *)
    numtype := nonumber;                     (* initially assume input is invalid *)
    number := 0.0;
    power := 0;
    scale := 0;
    position := 1;                            (* Start with the first character *)
    sign := 1;                (* Initially assume that the number is positive *)
    negpower := false;        (* Initially assume power (if any) is positive *)

    len := length(buffer);              (* Get the length of the input string *)
    if len > 0 then                    (* If we have something, then parse it *)
    BEGIN
      IF buffer[position] IN opset THEN
      BEGIN                                (* First character is a sign operator *)
        IF buffer[position] = '-' THEN sign := -1; (* Number may be negative *)
        position := position +1;     (* Go to the next position in the input *)
      END;
      IF buffer[position] IN ['0'..'9'] THEN
      BEGIN                                (* First character is a valid digit *)
```

Listing 1 continued on page 432

Listing 1 continued:

```
        numtype := intnumber;                         (* Number could be an integer *)
        REPEAT
          number := radix * number + Ord(buffer[position]) - Ord('0');
                      (* Translate the character into a number using 'Ord()' *)
          position := position + 1;
        UNTIL (position > len) OR (NOT(buffer[position] IN ['0'..'9']));
      (* Keep translating until we run out of characters or input is invalid *)
      END;
      IF position <= len THEN
      BEGIN                                 (*  We have something left to work with *)
        IF buffer[position] = decimal THEN
        BEGIN                                (* We have encountered a decimal point *)
          numtype := realnumber; (* Number isn't an integer, but may be real *)
          position := position + 1;
          WHILE  (position <= len) AND (buffer[position] IN ['0'..'9']) DO
          BEGIN
            number := radix * number + ord(buffer[position]) - ord('0');
            position := position + 1;
            scale := scale+1;           (* Count digits past the decimal point *)
          END;
        END;
        IF buffer[position] IN expset THEN
        BEGIN                   (* We have encountered a scientific notation marker *)
          position := position + 1;
          numtype := realnumber;              (* All scientific notation is real *)
          IF buffer[position] = '+' THEN position := position + 1;
          IF buffer[position] = '-' THEN
          BEGIN                (* Scientific notation has a negative power of 10 *)
            position := position + 1;
            negpower := true;
          END;
          WHILE  (position <= len) AND (buffer[position] IN ['0'..'9']) DO
          BEGIN
            power := radix * power + ord(buffer[position]) - ord('0');
            position := position + 1;
          END;
        END;
      END;
      WHILE scale > 0 DO
      BEGIN                    (* Move the decimal point to the correct position *)
        number := number / radix;
        scale := scale - 1;
      END;
      IF negpower THEN
        WHILE power > 0 DO
        BEGIN                    (* Divide by radix to compute the correct power *)
          number := number / radix;
          power := power -1;
        END
      ELSE WHILE power > 0 DO
        BEGIN                  (* Multiply by radix to compute the correct power *)
          number := number * radix;
          power := power -1;
        END;
    END;
    number := number * sign;               (* Now give the number the correct sign *)
    IF (position <= len) OR (len = 0) THEN numtype := nonumber;
  END;  (* numberize *)

BEGIN
  WHILE TRUE DO
  BEGIN
    Write('input? >');
```

Listing 1 continued on page 434

Listing 1 continued:

```
    Readln(buff);
    numberize(result, inputKind, buff);
    CASE inputKind OF
      realnumber : Writeln('The number is ',result, ' and is real.');
      intnumber  : Writeln('The number is ', trunc(result),' and is an integer.'
      nonumber   : Writeln('" ', buff, ' " is not a number.');
    END
  END;
END.
```

The length of the string is obtained, and the index pointer to individual characters within the string is set to point to the first character. The WHILE-DO loop does the work and operates as follows. First, the character is tested to see if it is a counting number. Then the value of the index is tested to see if it is less than the length of the character string. If both tests are passed, the first digit is computed by subtracting the ordinal value of '0' from the ordinal value of the first character. The index is incremented and the tests are performed again; the process repeats until either an invalid character is found or the entire string has been processed.

This parsing algorithm can be extended to accept a decimal point, optional plus and minus signs, and data input in the form of scientific notation as shown by the numberize procedure in the numbertest program of listing 1. Listing 2 shows sample input and output from the program.

We have found only one problem with this program: in any operating system, underflow and overflow conditions are possible, and we have not guarded against them here. You should either take care not to exceed the limits of your implementation, or modify this algorithm to protect against overflow and underflow. We have successfully used variations of this program for several years in places where error-free data input is critical.■

Listing 2: *Trial input characters and the numbertest program responses.*

```
input? >4.5
The number is  4.50000 and is real.
input? >4567
The number is 4567 and is an integer.
input? >3.4
The number is  3.40000 and is real.
input? >3.4000
The number is  3.40000 and is real.
input? >hi there
" hi there " is not a number.
input? >3.4e-10
The number is  3.40000E-10 and is real.
input? >1.2345E+12
The number is  1.23450E12 and is real.
input? >34.34e-03
The number is  3.43400E-2 and is real.
input? >+45
The number is 45 and is an integer.
input? >-34e-01
The number is -3.40000 and is real.
input? >
```

David F. Hinnant (2300 Avent Ferry Rd., Apt. G5, Raleigh, NC 27606) holds a B.S. degree in physics and is a Unix systems analyst with ITT Telecommunications. Michael B. Smith (2504-A East 3rd St., Greenville, NC 27834), a systems programmer at East Carolina University Computing and Information Systems, is a senior in applied physics at ECU.

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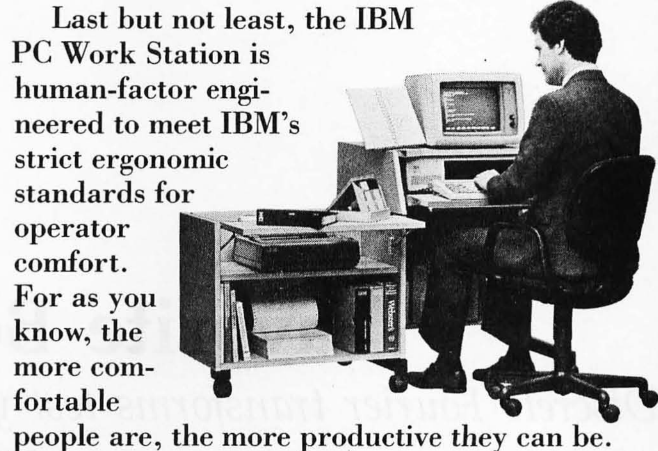
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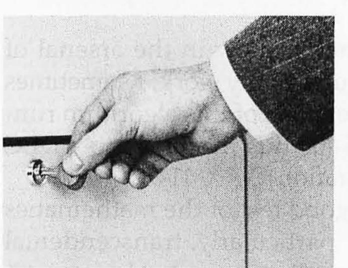
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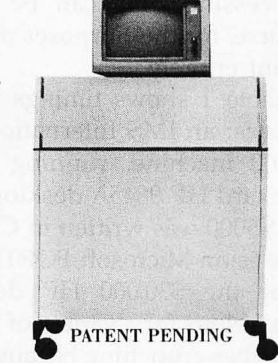


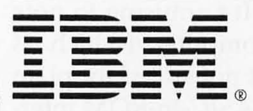
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Favorite Benchmarks

Discrete Fourier transforms test your computer's number-crunching ability

by Jeffrey L. Star

One of my favorite benchmarks is based on the calculations loop from a DFT (discrete Fourier transform) program.

The DFT algorithm is one of many in the arsenal of time-series analysis techniques. In my work, I sometimes need the DFT, and I have versions of this algorithm running on everything from S-100 bus machines to a DEC (Digital Equipment Corporation) VAX 11-780.

The code in listing 1 is a good test of the mathematics functions of a computer, particularly transcendental functions. The routine is basically two nested loops, with a final calculation of the square root of the sum of squares of trigonometric functions. Depending on the nature of the data you might feed to this calculation, the processing time can be decreased dramatically. Of course, for the purposes of a *benchmark,* this misses the point entirely.

Table 1 shows timings for this routine on two machines: an IMS International IMS5000 (a 4-MHz Z80A S-100 machine, running CP/M 2.2) and a Hewlett-Packard HP 9845A desktop computer. The code on the IMS5000 was written in CBASIC, CB-80, and in single-precision Microsoft FORTRAN-80. It's amusing to note that the $30,000 HP desktop computer (which is marvelous for a variety of tasks, but not suited for plain number-crunching because of its BASIC-in-ROM interpreter) is faster than the $5000 IMS5000's pseudointerpretive CBASIC (version 2) but slower when compared with compiler Microsoft FORTRAN-80. (A word of caution: both CBASIC and CB-80 use double-precision real-arithmetic, which explains their slow speeds.)

As table 1 illustrates, the time the routine takes increases roughly at the same rate as the square of the number of points. For some of the tasks I have to do around the lab, I need to calculate a 400-point DFT, which would take more than 12 hours using CBASIC! ■

Number of Data Points	HP 9845A	IMS5000 CBASIC	IMS5000 FORTRAN-80	IMS5000 CB-80
10	< 4	24	< 3	15
20	15	100	11	67
40	74	443	44	285

Table 1: *Timing measurements taken when running the benchmark shown in listing 1. Times are in seconds.*

Listing 1: *The benchmark algorithm expressed in CBASIC 2. The algorithm for this benchmark is actually the calculation loop from a DFT program and is especially useful when you're testing the mathematical functions employed by a system.*

```
REM *  PROGRAM DFT - CBasic 2
REM *    TIMING BENCHMARK FOR DISCRETE FOURIER TRANSFORM
REM *      J.L. STAR
REM *        APRIL 1981
        INPUT "What is the ORDER of the TEST?  ";N%
        DIM D(N%),F(N%)
        X1 = 0. : X2 = 1.
        I  = 1. : N = FLOAT(N%)
        D  = (X2-X1)/(N-1.0) : W1 = 0. : W2 = 3.1415926/(D*I)
        W3 = W2/(N-1.0) : B = 0. : T = 0.
        PRINT "** CREATING DATA VECTOR **"
FOR I% = 1 TO N%
        D(I%) = SIN(I%) + RND/3.
        NEXT I%
INPUT "HIT (RETURN) TO BEGIN CALCULATIONS......";LINE DUMMY$
PRINT CHR$(7)
FOR I% = 1 TO N%
        W = W3*FLOAT(I%-1) : C1 = 0. : S1 = 0.
        FOR M% = 1 TO N%
                G  = W*(X1 + FLOAT(M%-1)*D)
                C1 = C1 + D(M%)*COS(G)
                S1 = S1 + D(M%)*SIN(G)
                NEXT M%
        F(I%) = SQR(S1*S1 + C1*C1)*D
        NEXT I%
PRINT CHR$(7) : PRINT "** CALCULATIONS FINISHED **"
PRINT "       TRANSFORM" : PRINT
FOR I% = 1 TO N%
        PRINT USING "    ###  ####.#######";I%,F(I%)
        NEXT I%
END
A>
```

Dr. Jeffrey L. Star is a development engineer in remote-sensing research at the University of California (Santa Barbara, CA 93106).

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Apple Robotics

Dear Steve,

I am a 16-year-old Norwegian computer enthusiast who wishes to express his gratitude for your continuous inspiration. Living on the outskirts of computerdom, it often takes months for the latest news to get here.

I am presently planning a robot language and simulation on, and for, the Apple II Plus as a study project. My ambitious goal is to incorporate the Motorola MC68000. I also hope to have a dual operating system—voice/keyboard—as a part of the program.

I would like to have a few questions answered. How can the 68000 be incorporated in the Apple, and which high-level languages are available or can be applied? (I hope to write part of the program in Pascal.) With the chips now available, which is the best speech-recognition and speech-output setup for the Apple?

Thank you for any information you might have on these topics and for keeping the rest of the world in touch.

Erik Edward Syring
Sandvika, Norway

Digital Acoustics has a series of products and boards that interface the Motorola MC68000 to the Apple II. Various utility programs are available to interface some high-level languages. For further information, write the company at 1415 East McFadden, Ste. F, Santa Ana, CA 92705, (714) 835-4884.

There is no "best" speech-output system for the Apple. It depends on the intended application. If a large vocabulary is desired and speech quality is of secondary importance, a phoneme-type speech synthesizer is best. If extreme clarity of a limited number of words is desired, LPC (linear predictive coding) is the choice. If accents and music are required, an adaptive differential pulse code modulation system is worth considering. . . . **Steve**

New Zealand TV Standards

Dear Steve,

I have a homebrew computer with hexadecimal keypad entry and LED output. I want to convert it into a simple and inexpensive terminal by connecting it to a TV receiver. It would be easy to get a TV display using a 6847 display generator chip and an RF modulator except that the 6847 uses NTSC timing, and I don't want to modify the timing on my PAL-system TV set.

I am sure that a solution to this problem is available because the Radio Shack Color Computer, which uses the 6847, has a New Zealand version. I would appreciate your help.

Michael Stubbs
Auckland, New Zealand

The NTSC timing in the 6847 display generator chip can be modified for use with the PAL TV system. An article in the November 20, 1980 issue of EDN *magazine shows what is required. "Display Generator Chips Implement Smart Terminals" by Bissmire, Farrell, and Fletcher (pages 161–173) describes a complete smart terminal built around the Motorola MC6808 microprocessor and a 6847 display generator. Modifications for the PAL system are also presented. . . .* **Steve**

Dvorak Terminals?

Dear Steve,

As you are probably aware, many people are interested in the Dvorak keyboard layout because it is more efficient than the Qwerty design. Many people are converting to typewriters with the new layout, and some people want it on their computer systems. I have heard that some terminal manufacturers offer it as an option. Do you know of any such manufacturers? Thank you for your assistance.

Norman S. Frye
Grants Pass, OR

The Spring 1983 Peripherals Digest issue of Mini-Micro Systems *featured a product guide on alphanumeric terminals, listing some of their pertinent specifications. A column entitled "Special Features" was patently lacking in any reference to a Dvorak simplified keyboard (DSK) option. Manufacturers that boast an "ergonomic" design apparently do not consider DSK as ergonomic. However, this layout is gaining in popularity, and many typewriter manufacturers, such as Remington, Smith-Corona, Royal, and IBM, offer such an option. It will not be long before the major terminal manufacturers join the crowd.*

Write to some of the terminal manufacturers, requesting this option. They may offer it upon request but do not want to appear "revolutionary" by advertising it. . . . **Steve**

Apple Chips

Dear Steve,

I have an Apple II and an Amdek Video 300 monitor. The top five lines of the display don't line up with the other lines to form a straight column. By using the horizontal hold, I can get them to come close, the top line being 1½ characters off and the fifth line off only a little.

I tried a friend's Amdek Video 300, and the display was the same. I then tried my monitor on his Apple II Plus and the display was perfect. Also, when I hook up the color TV I formerly used, I have a hard time getting the color to come in satisfactorily. The color TV works okay on a normal TV station.

Do you have any suggestions on chips I can try replacing before I take my Apple in to be fixed?

Dave Partyka
Lorain, OH

The video problem with your Apple II is caused by a problem in the horizontal-synchronizing circuitry. The Apple uses a 14.318-MHz crystal oscillator as its master clock and divides the output down to generate, among others, the color subcarrier (3.58 MHz) and the horizontal line rate (15.734 kHz). This is accomplished by four 74LS161 counters labeled D11 through D14 on the motherboard. Refer to page 89 of the Apple II Reference Manual *for chip locations using this index. In addition, the output signals from the counters are processed through chips B14, B13, A12 (74LS02), and many others.*

First, check the 74LS161 counters by substitution and note any difference. Swapping with other chips of the same type on the board is a convenient way. Note any changes, and the defective chip perhaps can be isolated. Without the use of an oscilloscope, additional suggestions are not practical. If these tests are not fruitful, the best recourse is an authorized Apple

dealer. Sync problems can be nasty!. . . Steve

S-100 Advice

Dear Steve,

I want to gradually upgrade my present Exidy Sorcerer system. The first thing I need is an S-100 enclosure. I've looked at a lot of them, but I'm not sure which is best. Can you offer some advice? Thanks.

Walter Jeffries
Hanover, NH

S-100 mainframes consist of a motherboard, power supply, and cabinet. The better mainframes pay careful attention to each of these components. The motherboard should be made from high-quality fiberglass-epoxy material and have heavy-gauge copper traces. The trace areas for the power conductors should be wide enough for the anticipated current requirements. Shielded boards are preferred because they reduce RF radiation and cross talk. There should be either an active or passive termination of the bus lines to minimize noise and sufficient sockets for all anticipated additions. Extra sockets allow increased spacing of those cards that generate excessive heat or interact with adjacent boards.

The power supply should have sufficient capacity (usually 20 amps or greater) and be well filtered to reduce ripple. It should be properly fused and incorporate a line filter to eliminate transients and RFI. Premium mainframes include constant voltage transformers to improve regulation.

The cabinet itself should be of sturdy construction, include a fan to remove heat, and have a sufficient number of cutouts on the rear panel to accommodate serial and parallel connectors. AC convenience outlets are an added feature.

In general, you get what you pay for. . . . Steve

Secondhand Arcade Gear

Dear Steve,

At the local video arcades, I've noticed that some older machines are for sale. Would it be worthwhile to purchase one of these with the intent of improving or modifying the existing game? Is this possible for someone who is not an electrical engineer? Also, are these machines generally too dedicated to gaming for easy modification to serve a more general purpose?

David Young
Springfield, MO

Picking up used electronic equipment at bargain prices and investigating the mysteries of the machine can be a rewarding or a frustrating experience, depending on your purpose.

It can be rewarding from the standpoint that a lot can be learned by studying the designs of these pieces of equipment and what makes them work. It can also be frustrating because schematic diagrams are usually not available and any software built into the system cannot easily be decoded.

It may not be an impossible task to perform some simple modifications to a particular video game, but it will certainly be time-consuming, and you may wind up being a self-taught electrical engineer before you finish.

With the recent drop in prices of computers and home video games, it may cost more to modify an older video game than to purchase one new, depending on the type of game. . . . Steve

Apple + Heath

Dear Steve,

I recently completed a Heath H-89 and want to run Apple software on it. Is there a commercially available 6502 board that will work in my H-89? If not, is there an easy way of modifying the commonly available 6502 boards?

Aris Espejo
Ft. McMurray,
Alberta, Canada

I am not aware of a commercial product that will enable Apple II programs to run on your Heath H-89 computer. Adding a 6502 microprocessor board to the H-89 may allow programming in 6502 language, but the memory map would not be correct for Apple programs. The Apple makes extensive use of its monitor ROM programs and bit-mapped graphics. Your H-89 is configured as a terminal with character-mapped rather than bit-mapped graphics, so they would not be compatible.

Because much of the Apple operation is software controlled, it is easy to convert the Apple to run other processors by plugging in cards. The Apple functions, in effect, as a bit-mapped graphics terminal for the plug-in card. Going the other way is much more difficult. . . . Steve

Power Supply Considerations

Dear Steve,

I am trying to put together a system based on the S-100 bus. I have a commercial power supply that puts out +8 V at 25 A, +16 V at 3 A, and −16 V at 3 A. The power supply has no overvoltage or overcurrent protection. How important are these protective circuits? Is there a company that supplies them? Can you give me a simple design? Thanks.

Don Carlton
Hanahan, SC

Overvoltage and overcurrent protection in any system are always trade-offs between the price you want to pay for protection devices and the price you will pay if a failure occurs.

In an unregulated supply like the one you describe, the risk of an overvoltage situation is low if the input voltage remains within nominal tolerances. A commercial surge suppressor on the input to your supply should add sufficient protection from voltage surges in the AC line. A heavy-current supply like this one should also be properly fused on the primary side of the supply and on each DC supply.

Surge suppressors are sold by several advertisers in BYTE, such as Advanced Computer Products and Priority One Electronics.

In an S-100 bus system, some protection is also offered by the distributed voltage regulators on each card. The three-terminal regulators usually used for this application have built-in current limiting and can operate over a large input-voltage range. If you are concerned about a particular board, you could add an overvoltage sensor on board for extra protection. These devices monitor the supply voltage and fire a crowbar SCR (silicon-controlled rectifier) in the event of an overvoltage situation. You can find an overvoltage sensor at Radio Shack stores. . . . Steve

A German Commodore

Dear Steve,

I would like to buy a Commodore 64 with a disk drive. Next summer, however, I will be returning to Germany where electrical and TV standards are different. I know Commodore sells an appropriate version of this computer in Germany, but I don't want to wait that long.

Is there any way to modify the computer or get an adapter so that the American version will run in Germany? It should be no problem to make 110 volts out of 220, but what about 50 Hz out of 60? And is it possible to adapt the TV signal? Thank you very much for your help.

Bernhard Dick
Philadelphia, PA

A unique solution to this problem was described in the January 1983 Ask BYTE column ("Uninterruptible Power Supplies Problem Solved," page 481). The author of the solution, Richard T. Nicholls, used a Tripp Lite power inverter manufactured by Tripp Manufacturing Company to convert a 12-V battery voltage to 110 V, 60 Hz. Using this method, he was able to operate a TRS-80 Model I with no problems. The method also ensures uninterrupted power since it is battery powered. . . . **Steve**

Centronics Standard Revisited

Dear Steve,

Would you please tell me what the specifications for a Centronics parallel interface are? There seem to be an infinite number of devices and computers that use it. My computer doesn't have one, and I would like to put one together. Thank you.

John G. Lussmyer
Lowell, MI

The Centronics parallel interface is a de facto standard for a parallel printer port. In its simplest configuration, it consists of eight DATA lines, a STROBE line, an ACK (for acknowledge) line, and GROUND. There are several other signals, such as BUSY, PAPER EMPTY, and SELECT, but they are normally not required.

For the purposes of driving many of the parallel input printers on the market, it is necessary only to wire the lines as indicated below:

Pin	*Signal*
1	*STROBE*
2	*DATA 0*
3	*DATA 1*
4	*DATA 2*
5	*DATA 3*
6	*DATA 4*
7	*DATA 5*
8	*DATA 6*
9	*DATA 7*
10	*ACK*
16	*GROUND*

The STROBE and ACK lines are usually active low, but either or both can be active high, in which case an inverter circuit is necessary. . . . **Steve**

Affordable Tape Backup

Dear Steve,

We converted our office microcomputer (an Altos 8000-15) from floppy-disk to hard-disk storage about nine months ago. We have been using floppy disks for backup, but this has become rather cumbersome. Altos markets a stand-alone tape backup unit, but the price is $3500.

Does anybody manufacture a reliable after-market tape backup system for $1000 or less? Thank you.

C. D. Walker
Germantown, TN

Pegasus makes a 25-megabyte tape backup system for hard disks that is advertised for $695. You can contact the company at Pegasus, 2200 West Higgins Rd., Ste. 245, Hoffman Estates, IL 60195, (312) 843-1090. . . . **Steve**

High-Resolution S-100 Graphics

Dear Steve,

A large number of color monitors are available for the IBM PC and its clones but few for S-100 lovers, save some expensive units normally used for basic CAD/CAM applications. Numerous S-100 boards are offered for composite video, but I have been unable to find a suitable S-100 board that will drive an RGB monitor. And inasmuch as I want to configure an S-100 bus machine with an RGB monitor and IBM or Keytronic keyboard, I have a few questions.

First, do you know of an S-100 RGB board that provides, say, 680- by 480-pixel resolution with 16 full-attribute colors? Second, I have considered buying an IBM PC color board with the proper characteristics and kludging it to the S-100 bus, in view of the fact that they both are 8088-based. Do you think that I would face insurmountable problems in doing this, or would a careful mapping of the IBM system-board lines to the S-100 lines suffice?

Justin Farnsworth
Neuilly, France

Cambridge Development Laboratory (100 Fifth Ave., Waltham, MA 02154, (617) 890-8076) markets a board and software that will create high-resolution graphics on an S-100 system. An article describing this system appeared in the November 1982 BYTE. "Cambridge Development Lab's High-Resolution Video Graphics System" by James R. DeKock (pages 148–160) describes the system in detail.

If the rather high price of that system concerns you, you might consider the Microangelo board by Scion. It features 512- by 480-pixel graphics as well as 40-line by 85-character text. It sells for $795 in single quantities. For further information, write Scion, 12310 Pinecrest Rd., Reston, VA 22091, (703) 476-6100. . . . **Steve**

P.S. *I don't recommend kludges.*

European Modem Frequencies

Dear Steve,

I have built your ECM-103 modem (March 1983 BYTE, page 26), and it works fine. The only problem is that it operates only on U.S. frequencies. Is it possible to change it so that it can work on European frequencies?

Bjørn Haaland
Tomter, Norway

Texas Instruments has a modem chip designed to work on the European frequencies. The chip number is TMS99534, and it can be obtained from Texas Instruments or its distributors. It uses the same frequency crystal. Write to the company at Texas Instruments, Semiconductor Group, POB 202129, Dallas, TX 75220. . . . **Steve**

Floppy Disk Use Sans Computer

Dear Steve,

Is there any way to write a Teletype (TTY) signal (110-bps, 20-mA current loop) or an RS-232C signal (300 bps) to a 5¼-inch floppy disk without going through a computer? We have several gamma and liquid scintillation counters that currently output information to TTYs with punch-paper tape. In addition, one gamma counter is a microprocessor-based system that must communicate with the output device.

Because paper tape is an obsolete medium and a paper-tape reader is almost as expensive as the mainframe of our new microcomputer system, we would prefer to use floppy disks to transfer information. One option would be to interface the counters directly into the computer (go on line). However, we have six such instruments and would have to buy six micros or a minicomputer system with a multiuser operating system.

If we must go through a computer to write a disk, what is the least expensive computer one could use to write in a common disk format (Apple DOS 3.3, CP/M-80, etc.)? This may seem like a trivial question. However, a simple way to write a 5¼-inch floppy disk without going through a computer would have broad application in science and industry.

H. Edward Grotjan Jr.
Houston, TX

It is not necessary to interface your equipment through a computer system to store data on 5¼-inch floppy disks, although this certainly can be accomplished with most microcomputers available.

A system called the FDS-100 Minifile can be interfaced to an RS-232C serial port and will store data directly to 5¼-inch floppy disks. The FDS-100 is an intelligent minifloppy-disk system with built-in power supplies and can store up to 179K bytes per disk. The address of the manufacturer of the FDS-100 is Atek NC Corporation, 887 Main St., POB E, Monroe, CT 06468, (203) 268-1839.

Information on the type of disk format used in the FDS-100 should be available from the manufacturer. . . . **Steve**

RS-232C/RS-422A Interface

Dear Steve,

I have a used IBM 3101 video display that includes only an RS-422A interface. Could you please direct me to a source that shows how I can build an RS-422A-to-RS-232C converter so that I can use the 3101 with my OSI equipment? I also have some IBM boards that output eight RS-422A lines that I would like to use with my RS-232C devices. Any help you can provide will be appreciated.

Keith Brigode
Holland, OH

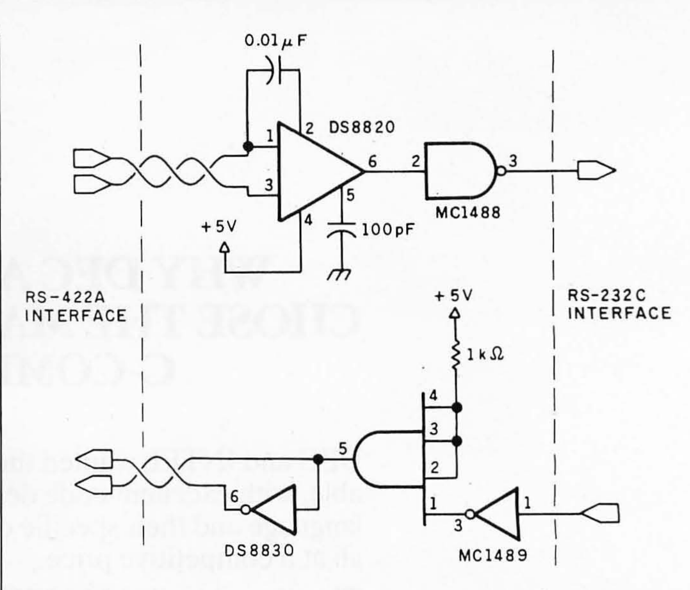


Figure 1: *A method for interfacing between the RS-422A and RS-232C standards.*

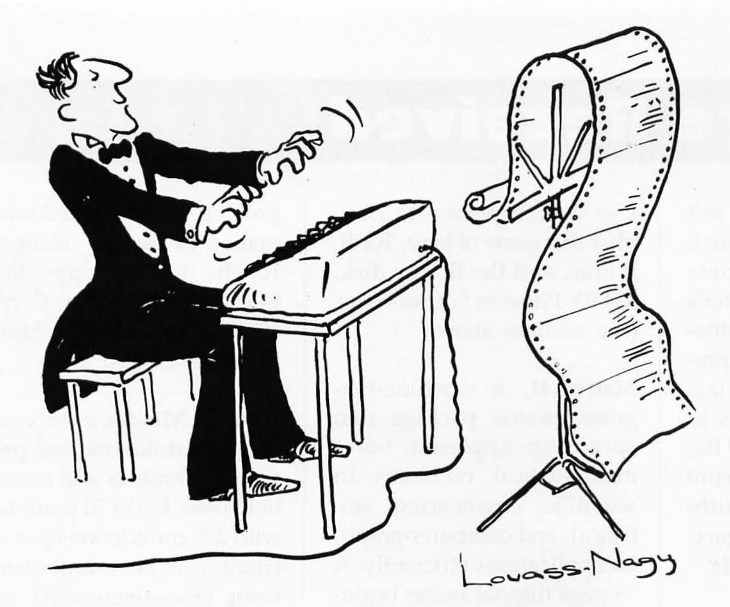
Your problem of communicating between pieces of equipment that contain different interfaces is not uncommon because of the numerous communication standards in use today.

The Electronic Industries Association (EIA) standard RS-422A is an upgraded version of the electrical specifications for the RS-232C interface. The main difference to note for your application is that the RS-422A uses balanced transmission while the RS-232C uses unbalanced transmission.

One method for interfacing between the two standards is shown in figure 1. The balanced transmission output from the RS-422A interface is converted to a TTL signal by a National Semiconductor DS8820 line receiver and then converted to an RS-232C-compatible signal by the MC1488 line driver. In the reverse direction, the RS-232C signals are converted to TTL levels by an MC1489 line driver and then converted to balanced-transmission signals by the DS8830 differential line driver. Proper signal polarity can be obtained by reversing leads at the RS-422A interface.

An excellent description of the differences between the RS-232C and RS-422A interfaces can be found in the article "Welcome to the Standards Jungle" (February 1983 BYTE, page 146). . . . **Steve■**

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:
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Software Received

Apple

Algebra Arcade, an arcade-type educational game. Design graphs to outwit the Graph Gobbler and Algebroids and simultaneously learn basic and advanced algebra. Choose your own level of play with equations ranging from straight lines to quadratic formulas. For II, II Plus, and IIe; floppy disk, $49.95. Wadsworth Electronic Publishing Co., 8 Davis Dr., Belmont, CA 94002.

Argos, an arcade-type game. To save Earth, you must destroy Argonians both in space and on land. Fight off waves of their missiles, spaceships, and parachutists. Requires a joystick. For II and II Plus; floppy disk, $34.95. Datamost Inc., 8943 Fullbright Ave., Chatsworth, CA 91311-2750.

Amphel's Simple Tenant Billing System, a tenant-billing procedure. Up to 500 accounts can be handled enabling rental-property owners and managers to keep track of rents, past-due payments, late charges, utility fees, and miscellaneous charges. For II and IIe; floppy disk, $99.95. Amphel Industries Inc., Suite 353, 2888 Bluff St., Boulder, CO 80301.

Bats in the Belfry, a strategic extermination game. Your job is to catch and dispose of bats that have infested an old schoolhouse before they reach its belfry. Avoid the fuzzballs and trapdoors that slow you down. If your score is high enough, you can become a Bat Master. For II, II Plus, and IIe; floppy disk, $29.95. Phoenix Software Inc., 64 Lake Zurich Dr., Lake Zurich, IL 60047.

The Exchange, a stock-market game with *high-resolution* graphics. Buy and sell stocks to make as much money as you can. Business tips from the computer's news service help you analyze market trends. Be prepared for capital-gains tax, splits, rises and declines in stocks. For II, II Plus, and IIe; floppy disk, $59.95. Kelcom Management Ltd., 30 Southampton Dr. SW, Calgary, Alberta T2W 0T5, Canada.

Enchanter, an interactive-prose fantasy game. Learn the wisdom of the medieval guilds from cartographers, orators, scriveners, physicians, and fletchers. These magical powers enable you to destroy the evil warlock, restore peace to the kingdom, and become an enchanter. For the II; floppy disk, $49.95. Infocom Inc., 55 Wheeler St., Cambridge, MA 02138.

Gnosis VII, a role-playing, educational adventure game. Mental horizons expand as you try to discover seven secret names in a mythical land called Gnosis. You must perform hierarchical, secular tasks that enhance cultural values. No two scenarios are the same. For II Plus and IIe; floppy disk, $19.95. Magnetic Harvest, POB 255, Hopkins, SC 29061.

Hypertyper, an educational typing program. Learn or improve typing skills at a pace and level that you select. Words per minute and accuracy percentage are displayed when you complete each exercise. For the II; floppy disk, $29.95. Summit Software Corp., Suite 2, 880 Second St., Santa Rosa, CA 95404.

Masquerade, a high-resolution graphics adventure game. You are a detective trying to break a tough case. All but one clue is a dead end. Use your expertise to decipher this game of logic. For II, II Plus, and IIe; floppy disk, $34.95. Phoenix Software Inc. (see address above).

Matrix II, a machine-language matrix package that speeds up Applesoft. Solve mathematical problems in scientific, engineering, statistical, and computer-graphics applications efficiently. A 36-page tutorial assists beginning and advanced users in matrix manipulations. For II Plus and IIe; floppy disk, $19.95. LRS Systems, 810 North Seventh, St. Charles, MO 63301.

The Money Manager: A Personal Finance Simulation. Teachers of high school personal-finance and consumer-education classes can use this program that simulates budgeting, banking, use of credit, insurance planning, consumer purchases, and income tax preparation. This teacher's guide includes a student workbook. For II, II Plus, and IIe; floppy disks, $74.95. Sterling Swift Publishing Co., 7901 South IH-35, Austin, TX 78744.

Personal Tax Planner 1983/84, a personal federal income tax planning program. Reduce your tax based on informed decisions about second jobs, investments, and the advantages or disadvantages of long- or short-term capital gains and losses. For the IIe; floppy disk, $99. Aardvark/McGraw-Hill, 1020 North Broadway, Milwaukee, WI 53202.

Plato's Cave, an educational program that compares evidence with inference. Players must confront the problem of trying to understand reality by seeking and analyzing information. This program requires active data probing within limited information-gathering abilities. For the II Plus; floppy disk, $49.95. Krell Software Corp., 1320 Stony Brook Rd., Stony Brook, NY 11790.

Portfolio Minder, a stock and bond portfolio-tracking program for brokers and household uses. Up to 50 portfolios with 200 transactions per account can be manipulated using cross-referencing and an editor. Printouts include realized and unrealized gains and losses, portfolio income, status, and other transactions. For II Plus and IIe; floppy disk, $125. Softcell, 13 Webster Ave., Hanover, NH 03755.

Round About, an arcade-type game. As the captain of the starship *Roundabout,* you must shoot down alien invaders to make outer space as safe as possible. The enemy travels in large packs and can assume various threatening shapes. For the II Plus; floppy disk, $29.95. Datamost Inc. (see address above).

Short Cuts, an applications-writing program. Add extra commands to Applesoft BASIC programming to sort data such as strings, real numbers, or integer arrays. Other features include error checking during input, print formatting, help screens, and user-defined error messages. For the II, II Plus, IIe, and III; floppy disk, $39.95. Penguin Software, 830 Fourth Ave., POB 311, Geneva, IL 60134.

Spare Change, a humorous arcade-type game in which you are the owner of a busy arcade. Unfortunately, your two best customers are trying to pilfer enough tokens to retire. Try to distract them by playing their favorite tunes, ringing pay phones, and

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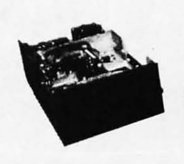
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Spell Perfect, a spelling-correction program that detects misspelled words. Reduce proofreading to a one-step process with easy prompts, a word count, a dictionary you create, and displays of words that are spelled similarly. For II, II Plus, and IIe; floppy disk, $89.95. LJK Enterprises Inc., 7852 Big Bend Blvd., St. Louis, MO 63119.

Unit Professional, a library unit to be used with programming in Pascal. You can solve some of the simpler problems of formatting and error checking on input and output before you code it. Screens and their fields are user-defined. For II Plus and IIe; floppy disk, $39. D & L Professional Micro-computing, 1201 Lincoln Ave., New Castle, IN 47362.

Wizardry—Legacy of Llylgamyn, a three-dimensional fantasy and adventure game. This is the third scenario in the Wizardry series in which you are one of the descendants of the heroes of the Knight of Diamonds. As such, you are to seek the dragon L'kbreth and regain the mystical orb to balance nature's upheavals. For II, II Plus, IIe, and III; floppy disk, $39.95. Sir-Tech Software Inc., 6 Main St., Ogdensburg, NY 13669.

Wordworx, two educational word games for all ages. Myspellery is a vocabulary builder in which you decode mystery words using as few clues as you can. Sentence Maker challenges your ability to invent grammatically correct sentences given a string of five letters. You can add your own myspelleries to challenge other players. For II Plus and IIe; floppy disk, $34.95. Reston Publishing Co., 11480 Sunset Hills Rd., Reston, VA 22090.

Atari

Capture The Flag, a two-player game for all ages. In a split-screen display, the invader must exit the three-dimensional labyrinth through one of two doors to reach the flag. If the defender touches you it will prevent you from capturing the flag. Adjusted tempo in music reflects action. For 800/1200; floppy disk, $39.95. Sirius Software Inc., 10364 Rockingham Dr., Sacramento, CA 95827.

Moviemaker, an interactive sequential-animation package in which you are a movie director. You devise the action, set the scene, and create actors, and the program plays back the completed computer-generated movie. For 800/1200; floppy disk, $60. Reston Publishing Co., 11480 Sunset Hills Rd., Reston, VA 22090.

Nightraiders, a space-war game. You have joined the Nightraiders corps to rescue Earth from tyranny. Destroy the enemy's military strength and cross the battlefield to attack the base. As you fly over enemy territory you encounter targets such as a tank, bridge, radar tower, missile, train cars, and more. For 800/1200; floppy disk, $29.95. Datamost Inc., 8943

Fullbright Ave., Chatsworth, CA 91311-2750.

Popeye, an arcade-type game. As Popeye, you must catch all of Olive's hearts, notes, and cries for help before they hit the water and sink. Eat spinach for strength but beware of Brutus, the Sea Hag, and vultures. Levels of difficulty increase. For 400/800/1200; cartridge, $40. Parker Brothers, 50 Dunham Rd., Beverly, MA 01915.

The Return of Heracles, a Greek mythology adventure game. When you become a Greek hero or heroine, Zeus will assign 12 tasks but will not offer any clues as to how to do them. The Oracle of Delphi has the advice you seek, but it's not free. For 800/1200; floppy disk, $32.95. Quality Software, Suite 105, 6660 Reseda Blvd., Reseda, CA 91335.

CP/M

Co-Sort, a sort-and-merge utility program. With this program you can sort small data sets using a fast algorithm without transferring files. It allows for fixed- or variable-length records, all data types, and provides many keys in any direction. Floppy disk, $200. Information Resources, Box W, Manhasset, NY 11030.

List-master, an information-management utility program for CP/M 2.2-based systems. You can keep track of lists including 30,000 data items, each with 252 characters. It includes a full-screen editor for data entry, sort and criteria-select procedures, and integrates with BASIC programs. Floppy disk, $149.95. Palace Software, RD #1, Box 331, Moundsville, WV 26041.

Magikey, a keyboard-enhancement program for version 2.2-based systems. This program lets you define and assign a string of characters to any key. Features include built-in batch-processing capabilities, console and printer I/O redirection, and extensive string-editing options. Floppy disk, $100. Pro Microsystems, 16609 Sagewood Lane, Poway, CA 92064.

Plotpro, a set of three Microsoft BASIC programs that make scientific applications graphs on any 80- or 132-column printer. Protemp creates templates of the physical appearance of any graph. Proquick controls plotting and printing of infinite-length graphs. Plotpro creates linear and logarithmic plots and can plot multiple functions on the same graph. Floppy disk, $49.95. BV Engineering, POB 3351, Riverside, CA 92519.

Commodore

Music Tutor, a set of six programs that teach beginning music students the basic elements of music. Programs include bass- and treble-clef notes, rhythms, symbols, music terms, and a review game. For the 64; cassette, $30. MKI Software, 15295 Oceana, Allen Park, MI 48101.

Portfolio Manager, a stock-market analysis program to assist in personal investments and financial management. Files let you create and update as many as 70 stocks based on current market quotes. You can thus spot

trends for buying and selling. For 64 and VIC-20; floppy disk and cassette, $29.95. Basic Byte Inc., POB 924, Southfield, MI 48037-0924.

Spectrum-64, a fast Fourier transform-analysis program for use in college junior to graduate-level calculus classes. This program finds the frequency spectrum or inverse for waveform or data analysis when you enter a signal or data sample. Applications include signal-spectral content, filter design and response, antenna-radiation patterns, convolution integrals, and a variety of other technical uses. For the 64; floppy disk and cassette, $79.95; $59.95 with proof of student or teacher status. Red-Shift Software, POB 45488, Seattle, WA 98145-0488.

Zeppelin Rescue, an arcade-type game. Your mission as the pilot of a blimp is to rescue hundreds of people stranded in a hazardous environment while keeping watch on your gas gauge and avoiding obstacles. Choose from five cityscapes and four levels of difficulty. Requires a joystick. For the 64; floppy disk, $24.95. Computer Software Associates Inc., The Silk Mill, 44 Oak St., Newton Upper Falls, MA 02164.

Heath/Zenith

Disarm.Com, an artificial-intelligence puzzle program. Using extensive graphics, a robot that learns additional command words through analysis is told how to disarm a bomb by remote control. For the H/Z-89; floppy disk, $35. Friendliware, POB 21206, Lansing, MI 48909.

Slabs.Com, a graphic adaptation of Towers of Hanoi. Try to rearrange the slabs in a minimum number of moves. For the H/Z-89; floppy disk, $15. Friendliware (see address above).

FLJ Soft, a graphics and printing program that helps you modify Zenith's interactive business graphics package to provide printing of graphs and pie charts. It's written in assembly language with a source code for customized modification. For the H/Z-100; floppy disk, $19.95. FLJ Software Co., POB 3293, Hialeah, FL 33013.

IBM Personal Computer

Acme Linear Optimization, a mathematical-formulation program that allocates limited amounts of resources to different projects to minimize costs and maximize profits. Only a basic knowledge of algebra is needed to operate for planning in business, marketing, engineering, and the environment. Floppy disk, $150. Acme Computer Co., 532 Northeast 83rd St., Seattle, WA 98115.

Enchanter, an interactive-prose fantasy game (see description under Apple). Floppy disk, $49.95. Infocom Inc., 55 Wheeler St., Cambridge, MA 02138.

The Exterminator, a BASIC-programming tool. This program uses labels instead of line numbers and lets you write a type of control statement. You can write programs in several different files and combine them in any order you select. Floppy disk, $49. Micromedia, POB 33071, Northglenn, CO 80233.

dB/RA, a dBASE II utility package. This array program permits the creation of a group of related data with a similar format, provides storage of over 65,000 memory variables, and allows access to data from up to 12 files simultaneously. Floppy disk, $200. Gryphon Microproducts, POB 6543, Silver Spring, MD 20906.

Harvard Project Manager, a project-planning and management program. This program aids in analysis, planning, and scheduling projects by determining which parts of the project are critical to the total project time. It also helps to efficiently schedule tasks at minimum cost while still meeting deadlines. Floppy disk, $395. Harvard Software Inc., Software Park, Harvard, MA 01451.

Investment Tax Analyst, a user-friendly series of Visicalc templates for accountants, stockbrokers, financial planners, and individual investors to analyze the tax implications of different investment strategies. This program can determine the total tax cost and effects of investments up to six years, both before and after investments have been made. Floppy disk, $150. John Wiley & Sons, 605 Third Ave., New York, NY 10158.

Least Squares Curve Fitter (LSF), a curve-fitting method package. This program is used to derive a relationship between sets of variables by collecting, storing, and retrieving large amounts of data for applications that include such fields as politics, mathematics, engineering, and finance. The three types of curves generated are linear, quadratic, and cubic. Floppy disk, $39.95. Prentice-Hall Inc., Rt. 9W, Englewood Cliffs, NJ 07632.

PC Life, a game centered on a simulation of a cell's life-cycle. Create a world with a life pattern for all single-cell beings to follow on the grid of your screen. Cells produce colorful kaleidoscopic-type patterns as they grow and die. Floppy disk, $24.95. PC-Ware, Department BMS1, POB 3174, Gaithersburg, MD 20878.

Planfin, an accounting program designed to forecast, budget, and figure discounted cash-flow for your business needs. It is menu driven and allows you to change values in areas such as production and sales, pricing, financing, inflation, foreign-exchange movements, and more. Floppy disk, $195. Business Software Pty. Ltd., 10 Help St., Chatswood, New South Wales 2067, Australia.

Plotpro, a set of three Microsoft BASIC programs (see description under CP/M). Floppy disk, $49.95. BV Engineering, POB 3351, Riverside, CA 92519.

Professional Tax Plan, a tax-planning program for such professionals as accountants, attorneys, trust officers, and insurance agents. This program lets you index tax years for 1985 and after. It offers ten-year averaging, capital-gain deduction, self-employment tax, taxable unemployment compensation, medical expenses, credit limitations, and other features. Floppy disks, $350. Aardvark/McGraw-Hill, 1020 North Broadway, Milwaukee, WI 53202.

Profin, a financial-analysis program. You can financially evaluate your investments including irreversible capital-gain projects. This menu-driven program lets you ask "What if. . ." questions. You can produce business-oriented forecasts, budgets, discounted cash flows, and returns on investments. Floppy disk, $295. Business Software Pty. Ltd. (see address above).



The personal, portable daisywheel printer.

Only $599.

For the first time, your letter-quality printer can be used almost anywhere! Bring the new Transtar 120 with you to work, to school, and home again! Conveniently weighing in at less than 19 pounds, it generates unrivaled print quality and is the size of a standard briefcase. The new 120 is so light, so small, that you can take it with you!

Remarkably, the new $599 Transtar 120 is "plug and go" compatible with the best-selling word processing programs. Just plug the 120 into your personal computer and watch this precision printer purr along at 14 cps Shannon text speed producing superscript, subscript, underlining and a true boldface. Even using letterhead is now a breeze with the 120's automatic single sheet loading!

Don't worry about durability: it's a tough little machine. It joins the highly reliable family of Transtar printers with a failure rate that's the envy of the industry: less than 1%. Should your 120 ever need repair, a nationwide network of authorized service centers stands ready for speedy repair on your six-month end-user warranty.

Just think of it: everything you want in a letter-quality printer...anywhere you want it. Only $599.

Transtar

P.O. Box C-96975, Bellevue, Washington 98009

Circle 362 on inquiry card.

Mr. Quartermaster, a menu-driven inventory-control system for businesses and institutions. This program lets you print reports for inventory, reordering, and usage listings. You can update stock and inventory items plus maintain comprehensive files with add, change, or delete. Floppy disk, $120. RJL Systems, 106 New Haven Ave., Milford, CT 06460.

1983 Tax Preparer, a program for professional, computer-automated preparation and filing of 1983 tax returns. It also keeps individual tax records throughout the year. Features include preprinted 1040 forms, instant access, a disk library, client-billing letter for professionals, and foolproof error recovery. Floppy disk, $250. Howard Software Services, Suite 310, 8008 Girard Ave., La Jolla, CA 92037.

Real Analyzer, a real estate program. You can analyze both income and home property over 5 years. This program will help you decide when it's best to buy, sell, exchange, or refinance any property by projecting cash flow and profitability before and after taxes. Floppy disk, $195. Real-Comp Inc., POB 1263, Cupertino, CA 95015.

RIP, a real estate investment package. This set of 12 Visicalc templates helps in time-consuming calculations. The analysis template will perform a detailed 8-year analysis on property by comparison of investment alternatives. Floppy disk, $29.95. Tom Ciulik, 3011 Bunker Hill Circle, Marietta, GA 30062.

Sailing, a sailing-adventure simulation game. You must sail your boat through the Caribbean Sea in a race against time to rescue swimmers trapped in the Bermuda Triangle. Beware of the creeping mist, gravitational vortices, storms, and other obstacles. Floppy disk, $34.95. Accupipe Corp., 222 West Lancaster Ave., Paoli, PA 19301.

Supercalc 3, an electronic spreadsheet with integrated graphics and data- and text-management capabilities. It is geared toward professional managers who need to solve financial and numerical analyses. You can create line and bar graphs and pie and exploded-pie charts. Floppy disk, $395. Sorcim Corp., 2310 Lundy Ave., San Jose, CA 95131.

Triple Brain Trust, a question-and-answer game for all ages. After a question is correctly answered, the player places an X or an O on a tic-tac-toe grid. Categories include word recognition, basic reading, geography, movies, and general sports trivia. Floppy disk, $39.95. Reston Publishing Co., 11480 Sunset Hills Rd., Reston, VA 22090.

TRS-80

The BASIC Answer, a text-processing utility program. BASIC programmers can construct code in a structured manner. It uses labels instead of line numbers and supports variable names of up to 14 significant alphanumeric characters. For the Model 4; floppy disk, $69. Logical Systems Inc., 8970 North 55th St., POB 23956, Milwaukee, WI 53223.

Games for the II (vol. 2), three arcade-type games. In Palestine, you pilot your fighter to destroy the enemy.

Software Received

In Ape Escape, you climb through the jungle to save Alvin Ape. And in Saucers, you help Andorians exterminate eight types of pests. For Models II, 12, and 16; floppy disk, $29.95. Maryland Model II Games, 3304 Carlton Ave., Temple Hills, MD 20748.

Kaleidophone, a programmable color-organ/video-music system. Create an unlimited variety of color displays that change in time with the music. You can play this like a video instrument or operate it from built-in displays. For the Color Computer; cassette, $20. New Salem Research, West Main St., New Salem, MA 01355.

LS-FED II (File Editor), an all-purpose file and disk editor. This utility program displays a 256-byte sector of a file in both ASCII and hexadecimal notation. Any byte of a displayed sector can be modified and you have several options for movement through the sectors. For the Model 4: floppy disk, $49. Logical Systems Inc. (see address above).

LS-FM (File Manager), a utility program for file management. It lets you display, kill, move, remove, and copy files. Wildcard characters can be used to purge a disk, and files can be copied to more than one disk drive simultaneously. For the Model 4: floppy disk, $49. Logical Systems Inc. (see address above).

LS-Help Generator, a utility program for use with LDOS Help that lets you create your own help files for use with LDOS. The Help Generator takes a text file and changes it into a data file that can be accessed with LDOS Help. For the Model 4: floppy disk, $49. Logical Systems Inc. (see address above).

LS-LDOS Help, a screen-oriented *utility* program that displays information about LDOS. Simply type HELP and a keyword to obtain information on LDOS or LBASIC commands. For Models I, III, and 4: floppy disk, $29. Logical Systems Inc. (see address above).

LS-Help Text Source, ASCII text files covering LDOS and LBASIC commands. The files may be incorporated into the LDOS Help utility or appended to create your own help files. For Models I, III, and 4; floppy disk, $29. Logical Systems Inc. (see address above).

LS-Technical Help, ASCII text files covering assembly-language programming with LDOS. The four files contain a description of the Z80 mnemonic functions, flag set/reset information, and op codes. For use with two disk drives and LDOS Help. For the Model 4; floppy disk, $39. Logical Systems Inc. (see address above).

Plotpro, a set of three Microsoft BASIC programs (see description under CP/M). For Models I, III, and 4; floppy disk, $49.95. BV Engineering, POB 3351, Riverside, CA 92519.

Pro-Cess, a menu-driven, machine-language program that provides maintenance for CMD- or CIM-type load-module files. It allows file appending, mapping, sorting, packing, offsetting, and partitioned data-set member extraction. You can reorganize large, inefficiently generated load modules. For the Model 4; floppy disk, $40. Misosys, POB 4848, Alexandria, VA 22303.

Smal-LDOS 5.1.3, a disk operating system based on a subset of LDOS. It features many of the filters and utili-

The Micromint Collection

Micromint. Supporting the varied projects that appear in Steve Ciarcia's monthly article in BYTE Magazine, "Ciarcia's Circuit Cellar." Offering a wide range of computers and peripherals designed to meet the exacting demands of the hobbyist as well as worldwide corporate clients.

TERM-MITE ST SMART TERMINAL BOARD

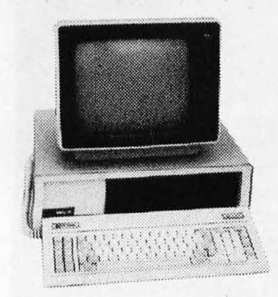
As featured in Ciarcia's Circuit Cellar BYTE Magazine, January & February 1984

All you need to build a Smart Video Terminal equivalent to the types advertised for $1,000.00 or more is a Term-Mite ST circuit board, scanned or parallel keyboard, video monitor and power supply.

- Uses brand new Nat'l Semi NS455A Terminal Processor.
- 24 lines by 80 characters, 25th reverse-video status.
- Upper & lowercase. Line (block) graphics.
- Selectable data rate, parity & display options.
- Reverse video, half intensity, double height & width, underlined, blinking and/or blank character.
- Separate sync or composite video output. Self Test.

Term-Mite ST Video Display Terminal Board
BCC22 Assembled & Tested .... $284.
BCC23 Complete Kit .... 244.

MPX-16 MICROCOMPUTER IBM PC COMPATIBLE



As featured on the cover of BYTE Magazine. Also featured in Ciarcia's Circuit Cellar November, December 1982 & January 1983

The Computer With A Split Personality.
—Use it as an IBM PC look alike that directly boots PC DOS 1.1 and accepts all expansion boards designed for the IBM PC.
—Use it as a powerful 8088 single board computer for all your OEM applications. Just add serial terminal, disk drive and power supply. Directly boots CP/M-86.

Buy the MPX-16 in the form that best meets your needs or budget. As a bare board, as a wave soldered board that contains all components less ICs, as an assembled and tested circuit board or as a complete system.

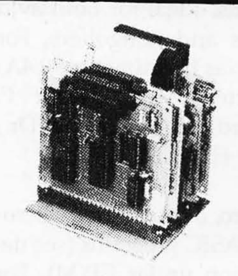
- Directly boots PC DOS 1.1 and CP/M-86.
- Most IBM PC software executes with no modifications.
- IBM PC bus compatible + 9 expansion slots.
- Intel 8088 16-bit microprocessor.
- Optional Intel 8087 math coprocessor.
- 256K bytes on board memory.
- Up to one megabyte of system memory.
- Up to 64K bytes of system ROM/EPROM.
- 2 RS-232C Serial & 3 Parallel I/O ports.
- Disk controller for 5¼" or 8" drives.
- Sixteen levels of vectored interrupts.

MPX-16 Circuit Board Assembled w/64K RAM .... $1,200.
OEM 100 quantity price .... 900.
MPX-16 Circuit Board Asembled w/256K RAM .... 1,400.
MPX-16 Semi-Kit (wave soldered circuit board w/all components) Less ICs ..... 595.
Complete Kit of ICs w/256K RAM .... 595.
MPX-16 Unpopulated (bare) PC Board .... 300.
CP/M-86 Operating System + Manuals ... 80.
MPX-16 Switching Power Supply .... 300.
MPX-16 Technical Reference Manual ..... 50.
MPX-16 Metal Enclosure with Fan .... 300.
Tandon TM 100-2 Double Sided/Density Drive .... 300.
IBM PC Keyboard Interface Adapter ...... 100.
Shipping & handling additional on all MPX-16 orders.

IBM PC is a trademark of International Business Machines Inc.
CP/M-86 is a trademark of Digital Research Inc.
Z8 is a trademark of Zilog Inc.

Circle 242 on inquiry card.

Z8 BASIC SYSTEM CONTROLLER NEW!!!



As featured in Ciarcia's Circuit Cellar. BYTE Magazine, July & August 1981

The Z8 Basic System Controller is an updated version of our popular BCC01. The price has been reduced and features added. The entire computer is 4" by 4½" and includes a tiny BASIC interpreter, up to 6K bytes of RAM and EPROM, one RS-232C serial port with switchable baud rates and two parallel ports. BASIC or machine language programming is accomplished simply by connecting a CRT terminal. Programs can be transferred to 2732 EPROMs with an optional EPROM programmer for auto start applications. Additional Z8 peripheral boards include memory expansion, serial and parallel I/O, real time clock, an A/D Converter and an EPROM programmer.

- Uses Zilog Z8 single chip microprocessor.
- Data and address buses available for 124K memory.
- Can be battery operated.
- Cross assemblers for various computers.

BCC11 Assembled & Tested .... $149.
New Low Price

Z8 MEMORY. I/O EXPANSION. CASSETTE INTERFACE

- 8K bytes of additional RAM or EPROM.
- Three additional 8 bit parallel ports.
- Cassette interface—300 baud K.C. Standard.
- Software real time clock.

BCC03 w/4K RAM Assembled & Tested ..... $150.
BCC04 w/8K RAM Assembled & Tested ..... 180.

Z8 EPROM PROGRAMMER

- Transfer BASIC or Assembly Language application programs from RAM to 2716 or 2732 EPROM.
- Comes with programming & utility routines on EPROM.
- Requires BCC03 Z8 Expansion Board for operation.

BCC07 Assembled & Tested .... $145.

Z8 ANALOG TO DIGITAL CONVERTER

- Uses Analog Devices 7581 IC, 8-channel 8-bit.
- Adds process control capability to the Z8 system.
- Over 1,000 conversions per channel per second.
- Monitors 8 analog signals in one of two 10v ranges.

BCC13 Assembled & Tested .... $140.

Z8 SERIAL EXPANSION BOARD

- Adds additional RS-232C and opto-isolated 20 ma. current loop serial port to the Z8 System.
- Runs at 75 to 19,200 baud in all protocols.
- Comes with listings of sample serial I/O routines.

BCC08 Assembled & Tested .... $160.

Z8 16K MEMORY EXPANSION BOARD

- Add up to 16K of additional memory, RAM or EPROM, to your Z8 System Controller in any multiple.
- Accepts 2016, 6116, 2716, or 2732 memory types.
- Four 16K cards may be installed on the Z8 System bringing the total memory to 64K.

BCC14 Assembled & Tested w/8K RAM ..... $120.
BCC16 Assembled & Tested w/16K RAM ..... 155.

COMING SOON! FORTH LANGUAGE VERSION OF THE Z8

With the new Z8 with on board 4K FORTH you can program high speed control functions in a few simple high level language commands. Perfect for data reduction, process control and high speed control applications.

BCC20 Z8F FORTH Microprocessor chip .... $150.
BCC21 Z8F FORTH System Controller (This board is a BCC11 with a BCC20 installed)
Assembled & Tested .... 280.

Z8 CROSS ASSEMBLERS

From Micro Resources
IBM PC, APPLE, 6502 Systems 5¼", CP/M 2.2 8" .... $ 75.
From Allen Ashley
TRS-80 Model I, III, Northstar 5¼" .... 75.
CP/M 2.2 8" .... 150.

Z8 FIVE SLOT MOTHER BOARD

- Expand your Z8 BASIC System with minimum effort.
- Contains five slots complete w/44 pin connectors.

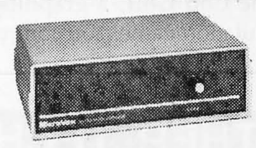
MB02 Assembled & Tested .... $69.

TRIPLE VOLTAGE POWER SUPPLIES

+5V @ 300 ma. +/−12V @ 25 ma.
UPS01 Assembled & Tested .... $35.
UPS02 Complete Kit .... 27.
+5V @ 1 Amp. +12V @ .5 Amp. −12V @ 50 ma.
UPS03 Assembled & Tested .... 60.
UPS04 Complete Kit .... 50.

SPEECH SYNTHESIZERS

MICROVOX TEXT-TO-SPEECH SYNTHESIZER



As featured in Ciarcia's Circuit Cellar BYTE Magazine September, October 1982.

Microvox is a second generation professional voice quality text-to-speech synthesizer that is easily interfaced to any computer, modem, RS-232C serial or parallel output device and provides speech of unbelievable clarity.

- Unlimited vocabulary.
- 64 programmable inflection levels.
- 6K text-to-speech algorithm.
- Full ASCII character set recognition and echo.
- RS232C and parallel output.
- 1000 character buffer, 3000 optional.
- Adjustable baud rates (75-9600).
- Spelling output mode.
- 7 octave music and sound effects.
- On board audio amplifier & power supply.
- X-On/X-Off handshaking.

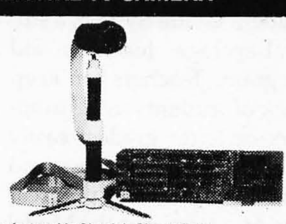
MV01 Assembled with 1K buffer .... $299.
MV02 Complete Kit with 1K buffer .... 219.
Add $15.00 for 3K buffer option.

VOTRAX SC-01A PHONETIC SPEECH SYNTHESIZER IC

The SC-01A Speech Synthesizer is a completely self-contained solid state device that phonetically synthesizes continuous speech of unlimited vocabulary. Used in our Microvox and Sweet-Talker.

SC01A Quantity 1–99 .... *$44. ea.*
100 + ... *32. ea.*
1000 + ... *24. ea.*

MICRO D-CAM DIGITAL TV CAMERA



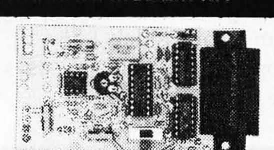
As featured in Ciarcia's Circuit Cellar BYTE Magazine, September & October 1983

GIVE YOUR COMPUTER THE DIMENSION OF SIGHT

- Interprets, enhances and stores images.
- 256 × 128 digital image sensor.
- Plug-in boards for the IBM-PC, APPLE II + or e.
- Software includes utilities for auto exposure, multi-level greyscale, screen dump and image enhancement.
- Includes interface card, 4 foot extension cable, camera assembly, manual, and software on diskette.

DC01 IBM PC Assembled & Tested .... $299.
DC02 IBM PC Complete Kit .... 264.
DC03 APPLE II Assembled & Tested .... 299.
DC04 APPLE II Complete Kit .... 264.

300 BAUD ANSWER/ ORIGINATE MODEM KIT



As featured in Ciarcia's Circuit Cellar BYTE Magazine, March 1983

Micromint's latest 300 Baud Modem Kit is crystal controlled, uses the TI TMS99532 IC, contains just 25 parts and requires no calibration or adjustments. Use with acoustic coupler or in direct connect mode.

MD04 Complete Kit as shown .... $60.
MD05 Transformer for Direct Connect Mode .. 9.
AC01 Acoustic Coupler Kit .... 20.

E-Z COLOR GRAPHIC INTERFACE WITH SPRITES

APPLE II E-Z Color plug-in board with Graphics Editor on 3.3 disk
EZ01 Assembled & Tested .... $150.
EZ02 Complete Kit .... 125.

APPLE II E-Z Color Plus
- Allows the use of a single monitor or TV set.

EZ11 Assembled & Tested w/Graphics Editor . $200.

KRELL LOGO for E-Z Color and E-Z Color Plus
Supports Sprite Graphics.
EZ21 Krell LOGO w/full documentation .... $89.

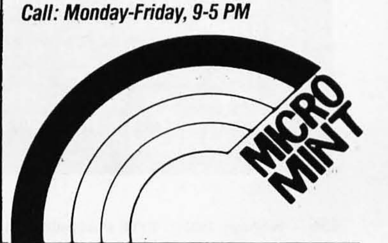
Animation Software for E-Z Color Plus
- Draw with Sprites using Joystick or Koala Pad.
- Animate Sprites from your own BASIC program.

EZ21 Animation Software .... $49.

S100 E-Z Color Graphics Board
- With sound generator & joystick interface.
- MBASIC Graphics Editor on 8" diskette.

EZ04 Assembled & Tested .... $289.

MICROMINT INC. *561 Willow Avenue, Cedarhurst, NY 11516*
To Order: *Call Toll Free 1-800-645-3479*
For Information Call: *1-516-374-6793*
Call: Monday-Friday, 9-5 PM



ties of the original system. For Models I and III; floppy disk, $59. Logical Systems Inc. (see address above).

Student Grade System, a student-average teacher's aid program. Teachers can keep track of students using numbers or letter grades, easily add or delete names, and print a student's progress during a term. For the Model III; floppy disk, $75. Tinker Techniques, 435 Greenway Ave., Trenton, NJ 08618.

Z Graph, a graphics-editor package in machine-language. Construct screen images using the computer's block-graphics capabilities. You can automatically generate lines, circles, and rectangles, or save any image generated from other programs. For Models I and III; floppy disk, $50. Misosys (see address above).

Timex/Sinclair 1000

AC and DC Circuit Analysis, two electronic-analysis programs. You can compute general numerical solutions to electrical circuits containing 12 nodes and 25 branches of resistors or controlled sources. The program also displays node and branch voltages, currents, and powers. Cassette, $15.95. Computer Heroes, 1961 Dunn Rd., East Liverpool, OH 43920.

1983 Tax Return Helper, a 1983 income tax calculation program. A set of five programs automatically correlates, updates lines, and checks errors when you enter information for Form 1040 and Schedules A, B, C, D, and E. Cassette, $14. K Soft, 845 Wellner Rd., Naperville, IL 60540.

RPNZL Programming System, a set of four programs that provides the speed and control needed in BASIC programming. It includes a 3000-bit-per-second tape system, a full-screen text editor, compiler, sampler, linker, and other features. Cassettes, $29.95. The Golden Stair, 141A Dore St., San Francisco, CA 94103.

Other Computers

Cape Cod Golf, a graphics-simulation game. You control the swing and make shots with a joystick on a 9-hole golf course. Try to par the course while avoiding trees, sand traps, and water hazards. Ideal for both avid golfers and nongolfers. For the Texas Instruments 99/4A; cassette, $14.95. Harry P. Richard, 18 Fruitwood Dr., Burnt Hills, NY 12027.

Plotpro, a set of three Microsoft BASIC programs (see description under CP/M). For Victor computers using MS-DOS; floppy disk, $49.95. BV Engineering, POB 3351, Riverside, CA 92519.

Supercomp-Twenty, an electronic spreadsheet for financial modeling and decision-support applications. This program is designed to be used in a distributed network so that models can be moved between different computers. You can also import data to a graphics or word-processing package. For the Digital Equipment Corporation (DEC) Professional 350; floppy disk, $395. Access Technology Inc., 6 Pleasant St., South Natick, MA 01760.■

This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.

Event Queue

February 1984

February-April
Courses from Integrated Computer Systems, various sites throughout the U.S. "Implementing Local Area Networks" and "Computer Network Design and Protocols" are two of the courses to be presented. For course information, contact Ruth Dordick, Integrated Computer Systems, 6305 Arizona Place, POB 45405, Los Angeles, CA 90045, (213) 417-8888.

February-April
Courses in C Language and Unix, various sites throughout the U.S. Three five-day courses are offered: "C Programming Workshop," "Advanced C Topics Seminar," and "Unix Workshop." For complete details, contact Joan Hall, Plum Hall Inc., 1 Spruce Ave., Cardiff, NJ 08232, (609) 927-3770.

February-July
Reliability and Maintainability Engineering Institutes and Short Courses, various sites throughout the U.S. A few of the programs to be offered are "Reliability Engineering, Testing, and Maintainability Engineering" and "The Tenth Annual Reliability Testing Institute." For a complete schedule, contact Dr. Dimitri Kececioglu, College of Engineering, Aerospace and Mechanical Engineering Department, University of Arizona, Tucson, AZ 85721, (602) 621-2495.

February-August
Conferences and Expositions from the Society of Manufacturing Engineers, various sites throughout the U.S. and around the world. More than 25 conferences and expositions are scheduled. For a calendar, contact the Public Relations Department, Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-0777.

February 13-16
Kuwait Info '84, International Exhibition Center, Kuwait City, Kuwait. Exhibits in this third annual event will encompass a broad range of information businesses, including data and word processing, communications, office automation, micrographics, security systems, and environmental control systems. Information is available from Carol Purdey, Intermarket Network Corp., Suite 203, 1110 Vermont Ave. NW, Washington, DC 20005, (202) 822-9127.

February 14-15
The First Annual Automated Manufacturing Systems Conference: A Market Assessment, Inn of Westchester, White Plains, NY. For information, contact Carol Sapchin, Frost & Sullivan Inc., 106 Fulton St., New York, NY 10038, (212) 233-1080.

February 14-16
The Twelfth Annual ACM Computer Science Conference, Franklin Plaza Hotel, Philadelphia, PA. Papers, panel sessions, and abstracts will address the central themes of "Factory of the Future," "Coping with Small Computers," and "Social and Ethical Implications of Computers." Exhibits will feature over 50 computer and instructional materials. Particulars are available from the Association for Computing Machinery, 1133 Avenue of the Americas, New York, NY 10036, (212) 265-6300.

February 15-16
Intermountain Telecommunications Show, Expomart, Salt Lake City, UT. This show, cosponsored by Jon Taylor & Company and the Utah Telecommunications Management Association, will focus on the latest developments in voice- and data-communications equipment and services. For information, contact Jon Taylor & Co., POB 356, Salt Lake City, UT 84110, (801) 298-3100.

February 17
Computer-aided Manufacture for Semiconductor Fabrication Applications, Palo Alto, CA. This intensive short course, sponsored by Continuing Education in Engineering and the College of Engineering of the University of California in Berkeley, will survey CAM trends. Advanced registration is required due to limited enrollment. The fee is $215. For information, contact Continuing Education in Engineering, University of California Extension, 2223 Fulton St., Berkeley, CA 94720, (415) 642-4151.

February 17-19
Computer Expo '84, Expo Centre, Orlando, FL. This show will feature more than 100 demonstrations of microcomputer hardware and software. Attendees can participate in a wide range of seminars and hands-on workshops. For details, contact Laurel Netzer, POB 3435, Longwood, FL 32750, (305) 862-6917.

February 18-22
Euroshop 84, Fairgrounds, Dusseldorf, West Germany. This international trade fair will feature more than 600 exhibitors from 20 countries and will be supplemented by workshops exploring various facets of the merchandising business. For show details, contact Dusseldorf Trade Shows, 500 Fifth Ave., New York, NY 10110, (212) 840-7744. For information on travel and arrangements, contact the Housing Division at (800) 221-3302; in New York, (212) 974-1934.

February 20-22
The 1984 Office Automation Conference (OAC '84), Convention Center, Los Angeles, CA. The theme of this conference is "Office Automation and You." For the first time, an executive-only program will be offered. Further information is available from the American Federation of Information Processing Societies Inc., 1899 Preston White Dr., Reston, VA 22091, (703) 620-8926. For details on the Executive Program, contact John J. Connell, Office Technology Research Group, POB 65, Pasadena, CA 91102.

February 20-23
Arabian Productivity Advancement Using Computers/Graphics, APAC '84, Inter-Continental Hotel, Riyadh, Saudi Arabia. This is the first international conference and exposition on computer graphics to be held in Saudi Arabia. Industry and government representatives from Middle Eastern and Western nations will attend. For information, contact APAC '84 Conference Director, World Computer Graphics Association Inc., Suite 399, 2033 M St. NW, Washington, DC 20036, (202) 775-9556.

February 21
High-resolution Lithography, Palo Alto, CA. This intensive short course, sponsored by Continuing Education in Engineering and the College of Engineering of the University of California in Berkeley, will focus on advances in electron-beam lithography, optical lithography tools, and more. Advanced registration is re-

quired due to limited enrollment. The fee is $215. For information, contact Continuing Education in Engineering, University of California Extension, 2223 Fulton St., Berkeley, CA 94720, (415) 642-4151.

February 21-23
Softcon, Superdome, New Orleans, LA. This international software conference and trade fair is designed for retailers, independent sales organizations, consultants, government agencies, educational institutions, and professional software developers. Registration is $15. For information, contact Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167, (800) 841-7000; in Massachusetts, (617) 739-2000.

February 22-24
Fundamentals of Finance and Accounting Using a Microcomputer, New York City. This three-day seminar is sponsored by the Data Processing Institute of the New York University School of Continuing Education. It will cover microcomputer applications for effective decision making and controlling business requirements. Previous computer knowledge is not required. The fee for the course is $695. For details, contact the NYU School of Continuing Education Seminar Center, 575 Madison Ave., New York, NY 10022, (212) 748-5094.

February 22-24
Pick Spectrum '84, MGM Grand Hotel, Reno, NV. This business-computer forum, designed for people in computer education and the technical or manufacturing paths, will feature a wide array of demonstrations and exhibits. Seminars will be available on Pick implementations, networking, magnetic tape media, and voice response and recognition. The fee is $350. To register, contact International Database Management Association Inc., Suite 210, 9740 Appaloosa Rd., San Diego, CA 92131, (619) 578-3152.

February 22-28
Imprinta 84, Fairgrounds, Dusseldorf, West Germany. This international congress and exhibition will feature techniques and services in print communication and its alternatives. For details, contact Dusseldorf Trade Shows, 500 Fifth Ave., New York, NY 10110, (212) 840-7744.

February 23-24
Computers in Construction, Orlando, FL. This seminar is designed to assist construction contractors and construction management firms in acquiring computer systems. The fee is $425 per registrant. More details are available from CIP Information Services Inc., 1105-F Spring St., Silver Spring, MD 20910, (301) 589-7933.

February 23-26
Technology, Entertainment, Design Communications Conference, Conference Center, Monterey, CA. Audio and visual presentations documenting technological advances and their usage in communications processes will be presented at this conference. Registration fees are $475. Contact Judi Skalsky, T. E. D. Communications Conference, 635 Westbourne Dr., Los Angeles, CA 90069, (213) 854-6307.

February 25-26
Computers & Reading/Learning Difficulties, Hilton, San Francisco, CA. This second annual conference is designed for those people who use computers in the reading and language arts, and for overcoming learning disabilities. Interested persons may request brochures from Educational Computer Conferences, Department N, 1070 Crows Nest Way, Richmond, CA 94803.

February 25-26
The Computer Supermarket Personal Computer Show, County Fairgrounds, San Mateo, CA. Retailers, manufacturers, and distributors will offer savings on a wide variety of personal computers, software, and accessories for hobby, business, and home uses. For exhibitor and show information, contact Microshows, POB 4323, Foster City, CA 94404, (415) 571-8041.

February 27-28
Software Tools for Distributed Support Systems, Westin Hotel at Copley Place, Boston, MA. This conference, targeted at managers and professionals, will feature in-depth demonstrations and discussions by leading software vendors. For details, contact Dr. Warren Briggs, The Software Tools Conference, Suffolk University, Beacon Hill, Boston, MA 02114, (617) 723-4700.

February 27-29
Fundamentals of Finance and Accounting Using a Microcomputer, Chicago, IL. For details, see February 22-24.

February 27-29
Micro Technology & Auditing, Westin Peachtree Plaza, Atlanta, GA. This intensive conference provides an update on state-of-the-art technology, controls, security, and auditability of microcomputer systems. Topics to be presented include a Unix system tutorial, recovery management for microcomputers, encryption, the Pick operating system, and the portable audit office. For details, contact MIS Training Institute Inc., 4 Brewster Rd, Framingham, MA 01701, (617) 879-7999.

February 27-March 2
MICAD '84, Paris, France. An exhibition associated with the MICAD biennial conference will be held for the first time. This event also marks the tenth anniversary of MICADO, the French Computer Graphics Association. MICAD will provide an opportunity for manufacturers of computer graphics hardware and software to make contact with the rapidly growing French computer-graphics market. For information, contact Caby Smith, World Computer Graphics Association Inc., Suite 399, 2033 M St. NW, Washington, DC 20036, (202) 775-9556. In Europe, contact MICADO, ZIRST, Chemin de Pre Carré, 38240 Meylan, France; tel: (76) 90-31-90; Telex: 980 882 F.

February 27-March 2
Welcome to the World of Personal Computing, Fort Lauderdale, FL. This workshop serves as a comprehensive introduction to the uses of microcomputer technology in business, industry, and government. Six modules, ranging from user productivity to software reliability, are on the agenda. For further information, contact Keston Associates, 11317 Old Club Rd., Rockville, MD 20852, (301) 881-7666.

February 28-29
The Twelfth Annual Midwest Digital Equipment Exhibit and Seminar, Thunderbird Motel, Minneapolis, MN. More than 100 manufacturers of computer terminals, data-communications equipment, peripherals, data-acquisition systems, and digital test instruments will display their products. Admission to both the exhibits and seminars is free of charge. For more details, contact Countryman Associates Co., 1821 University Ave., St. Paul, MN 55104, (612) 645-9151.

February 28–March 1
The Annual Computer Fair of the Computer Society of Bermuda, Princess Hotel, Southampton, Bermuda. The theme for this event is "Bermuda—The International Offshore Software Mart." Seminars, demonstrations, presentations, and vendor exhibits will highlight this show. For full details, contact James H. Young Jr., Computer Society of Bermuda, POB 1479, Hamilton 5, Bermuda, (809) 295-7111.

February 28–March 1
COMPCON Spring '84, San Francisco, CA. For details, contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-8142.

February 28–March 2
The Air Force Conference on Technology in Training and Education, School of Health Care Sciences, Sheppard Air Force Base, TX. This conference will explore technology in aerospace applications, technical training, and education, with emphasis on current developments in the Department of Defense. Topics of discussion include computer-generated simulations and training aids and innovative uses of interactive videodiscs. For information, contact Captain Jim Campbell, SHCS/USAF/MSSA, SAFB Wichita Falls, TX 76311, (817) 851-6461.

March 1984

March 1–2
The Microcomputer Jungle: Impact on Health Care, Kansas City, KS. This course is designed to broaden the knowledge base for novice, intermediate, and advanced small system users who work in health-care fields. The fee is $90 for physicians, nurses, therapists, and administrators; $45 for student/residents. For details, contact Jan Johnston, Office of Continuing Education, University of Kansas Medical Center, 39th and Rainbow, Kansas City, KS 66103, (913) 588-4480.

March 6–8
Professional Development Week '84 (P.D.W. '84), Holiday Inn, Ottawa, Ontario, Canada. The theme of this event sponsored by the Data Processing Institute is "Technology—Solution or Problem." Held in conjunction with Interchange '84, both events will cover various government electronic data processing applications and systems. For information, contact the Data Processing Institute, Box 2458, Station D, Ottawa, Ontario K1P 5W6, Canada, or call Carol Halikas at (613) 992-3333.

March 8–9
Computers in Construction, San Diego, CA. For details, see February 23–24.

March 8–10
The Role of the Microcomputer in Education IV, Arlington Park Hilton, Arlington Heights, IL. In-depth seminars and sessions covering a wide range of educational topics make up this conference. Further information is available from Rick Nelson, Micro-Ideas, 1335 North Waukegan Rd., Glenview, IL 60025, (312) 998-5065.

March 12–14
Auditing and Controlling Microcomputers, Houston, TX. This seminar reviews the technology behind microcomputers and shows how they can be used by an audi-

tor for practice management or as a tool in an audit engagement. For a course outline, contact Miriam Hoyt, MIS Training Institute Inc., 4 Brewster Rd., Framingham, MA 01701, (617) 879-7999.

March 12–15
Interface '84, Convention Center, Las Vegas, NV. For details on this twelfth annual data communications/information-processing conference and exposition, contact the Interface Group Inc., 300 First Ave., Needham, MA 02194, (800) 325-3330; in Massachusetts, (617) 449-6600.

March 13
NorWesCon-84, Red Lion Inn Convention Center, Bellevue, WA. The theme of this ninth annual Pacific Northwest industrial electronics trade show is "Discover Solutions in Technology." Almost 50 manufacturers will present exhibits, demonstrations, and seminars of original equipment manufacturing and end-user products for the industrial electronics marketplace. Admission is free for all members of the industry. For information, call the sponsor, Almac Electronics Corp., 14360 Southeast Eastgate Way, Bellevue, WA 98007, (206) 643-9992.

March 13–15
CIMCOM, Convention Center, Washington, DC. The Computer-integrated Manufacturing and Communications (CIMCOM) conference and exposition is sponsored by the Computer and Automated Systems Association of the Society of Manufacturing Engineers (CASA/SME). It will focus on software development and applications, beginning with manufacturing planning and continuing through the manufacturing-control processes. For informaiton, contact CASA/SME, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-1500, ext. 521.

March 13–15
Micro/SET 84: Microcomputer Expo for Scientific, Engineering, and Technology, Engineering Society of Detroit, MI. Papers emphasizing microcomputer applications in research, design, engineering, and manufacturing will be presented. Complementing the conference program will be displays of scientific, engineering, and technical microcomputer hardware and software. For more information, write to the Conference Manager, Engineering Society of Detroit, 100 Farnsworth, Detroit, MI 48202.

March 13–15
Optical Storage of Documents and Images, Biltmore Hotel, Los Angeles, CA. Topics to be covered are read-write and read-only storage of analog and digital information including office documents, engineering drawings, and parts catalogs. The fee is $695 for the first person from an organization and $595 for each additional attendee. For more information, contact Technology Opportunity Conference, POB 14817, San Francisco, CA 94114-0817, (415) 626-1133.

March 15–16
Technology Outlook, the Wisconsin Center, Madison, WI. This seminar, conducted by the University of Wisconsin—Extension Engineering and Applied Science Program, is for industrial executives seeking an understanding of telecommunications, automation, computer advances, and genetics. The fee is $475. For information, contact the University of Wisconsin—Extension, Department of Engineering and Applied Science, 432 North Lake St., Madison, WI 53706, (608) 262-3748.

March 18-22
Saudicomputer '84—The Business Computer Show, al-Dhiafa Exhibition Centre, Riyadh, Saudi Arabia. For information, contact Philip Jenkinson, Saudicomputer '84, Overseas Exhibition Services Ltd., 11 Manchester Square, London W1M 5AB, England; tel: 01-486 1951; Telex: 24591 Montex G.

March 19-21
Material Characterization Techniques for Integrated Circuit Processing, San Mateo, CA. This three-day course is designed to acquaint participants with current techniques for integrated-circuit development, process monitoring, and failure analysis. The course fee is $450 for lectures only or $695 for the third-day lab session. For information, contact Continuing Education in Engineering, University of California Extension, 2223 Fulton St., Berkeley, CA 94720, (415) 642-4151.

March 19-22
Automated Manufacturing Conference and Exhibition (AM84), Textile Hall, Greenville, SC. The latest automated manufacturing technologies will be the focus of this combination exhibition and seminar. Representatives from more than 200 firms are expected. Complete details about the conference can be obtained from the AM84 Registration Control Center, POB 5616, Station B, Greenville, SC 29606, (803) 242-3170, ext. 260. Details about the exhibition are available from AM84, POB 5823, Greenville, SC 29606, (803) 233-2562.

March 19-22
The Eighth Annual Federal Office Systems Expo (FOSE '84), Convention Center, Washington, DC. The theme for this year's expo is "Realities of Integration: Technologies, Applications, Human Resources." More than 60 conference sessions and 1200 exhibits are planned. Address inquiries to Jacqueline Voigt, National Trade Productions, 9418 Annapolis Rd., Lanham, MD 20706, (800) 638-8510; in Maryland, (301) 459-8383.

March 22-23
Computers in Construction, New York, NY. For details, see February 23-24.

March 22-25
The Ninth West Coast Computer Faire, Civic Auditorium and Brooks Hall, San Francisco, CA. This is one of the year's largest computer shows. For information, contact the Computer Faire Inc., Suite 201, 181 Wells Ave., Newton, MA 02159, (617) 965-8350.

March 23
The 1984 Computer Law Institute, Cleveland, OH. This event, sponsored by the Bar Association of Greater Cleveland, will cover current legal and tax issues that affect the computer industry. For details, contact Carole Falcone, Mall Building, Cleveland, OH 44114, (216) 696-3525.

March 26-28
The Seventh International Conference on Software Engineering, Orlando, FL. This conference seeks to evaluate what has been learned from the past and to provide directions for future investigations in software engineering. Its theme is "Fifteen Years of Software Engineering: Results and Futures." A software tools fair will be held concurrently. Contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

March 26-29
Personal Computer Interfacing and **Scientific Instrument Automation**, Blacksburg, VA. These hands-on

workshops, sponsored by the Virginia Polytechnic Institute and State University, provide participants with experience in wiring and testing interfaces on popular personal computers. For information, contact Dr. Linda Leffel, C.E.C., Virginia Tech, Blacksburg, VA 24061, (703) 961-4848.

March 26-30
The Sixth NC Industrial Automation and Robot Conference and Exhibition, Milan Fair, Milan, Italy. Controls for automated material handling, variable mission manufacturing systems, and quality control will be featured. A concurrent conference consisting of 20 sessions will be presented. For more information, contact the Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-0023.

March 27-29
Southwest Computer Conference (SWCC), Myriad Convention Center, Oklahoma City, OK. This seventh annual business and industry conference is aimed at management and technical personnel. It will feature more than 50 seminar presentations and 250 exhibits. For details, contact E. Z. Million, SWCC, POB 950, Norman, OK 73070, (405) 329-3660.

March 28-30
The Sixth Annual Computer Graphics Conference, Doral Hotel On-the-Ocean, Miami Beach, FL. The theme for this conference is "Forecasts and Assessments." Further details are available from Carol Sapchin, Frost & Sullivan Inc., 106 Fulton St., New York, NY 10038, (212) 233-1080.

March 30-31
Third Annual Conference on Communication Technology, Joseph Stokes Auditorium, Children's Hospital of Philadelphia, PA. This program presents advances in technology and treatment alternatives for physically handicapped and speech-impaired persons. Speakers, equipment demonstrations, and workshops are planned. The two-day registration fee is $95, which includes all course materials. If your registration request is postmarked before March 10, the fee is $85. Group rates are offered. For full particulars, contact Joan Bruno, Children's Seashore House, 4100 Atlantic Ave., POB 4111, Atlantic City, NJ 08404, (609) 345-5191, ext. 278.

March 30-April 1
The NY Personal Computer Show, Exposition Rotunda, Madison Square Garden, New York City. Formerly called the Eighty/Apple/PC Computer Show, this event will feature products and services for all small computer systems. Complete show details can be obtained from the Kengore Corp., POB 13, Franklin Park, NJ 08823, (201) 297-2526.

April 1984

April 1-4
The 1984 EFT Expo, Hyatt Regency, Grand Cypress Resort, Orlando, FL. This annual convention and exposition, sponsored by the Electronic Funds Transfer (EFT) Association, provides the opportunity to meet with leaders and experts in the field of automated payments systems and services. The fee is $495 for EFT members and $625 for nonmembers. For details, contact the EFT Association, Convention

Coordinator, Suite 800, 1029 Vermont Ave. NW, Washington, DC 20005.

April 2-4
Speech Tech—84, St. Moritz Hotel, New York City. This voice-synthesis and recognition applications show covers voice input/output as applied to computers, telecommunications, defense electronics, robotics, education, and aids for the handicapped. For information, contact Stanley Goldstein, Media Dimensions Inc., 525 East 82nd St., New York, NY 10028, (212) 680-6451.

April 2-5
The 1984 Test & Measurement World Expo, Brooks Hall, San Francisco, CA. This is the third annual expo sponsored by *Text and Measurement World,* a magazine from Interfield Publishing. For details, contact Meg Bowen, Test & Measurement World Expo, 215 Brighton Ave., Boston, MA 02134, (617) 254-1445.

April 3-5
Cincinnati Business Show, Convention-Exposition Center, Cincinnati, OH. Exhibits include automated office equipment, computers, communications, telephone systems and equipment, word processors, business systems and forms, and software and computer peripherals. For information, contact Weber and Associates Inc., 10608 Millington Court, Cincinnati, OH 45242, (513) 791-6303.

April 3-6
DEXPO East 84, Bayside Exposition Center, Boston, MA. This conference, dedicated to professionals who use Digital Equipment Corporation (DEC) equipment, is sponsored by the national independent DEC user group of Warwick, Rhode Island. Topics to be covered are office automation, personal computers, communications, security and disaster planning, education, graphics, technology trends, and other areas of interest. For information, contact Expoconsul International Inc., 55 Princeton-Hightstown Rd., Princeton Junction, NJ 08550, (609) 799-1661.

April 4-11
CeBIT, Hannover, West Germany. This office-equipment and data-processing technology exhibition will bring together exhibitors from more than 25 countries. For information, contact Hannover Fairs Information Center, POB 338, Route 22 E, Whitehouse, NJ 08888, (800) 526-5978; in New Jersey, (201) 534-9044.

April 5-7
COMDEX/Winter, Convention Center, Los Angeles, CA. This conference and exhibition will feature separate hardware and software sections on the same exhibit floor. For information, contact The Interface Group Inc., 300 First Ave., Needham, MA 02194, (800) 325-3330; in Massachusetts, (617) 449-6600.

April 8-11
World Retailers Business & Equipment Exposition, Palais des Congres, Paris, France. This exposition is sponsored by the National Retail Merchants Association (NRMA) and runs concurrently with NRMA's Ninth World Conference of Retailers. The exposition is designed to introduce store merchants to new developments, equipment, and procedures. Admission is free, although retail store merchants must show ticket. For complimentary *tickets and* details, write to Dan Soskin, NRMA Enterprises, 100 West 31st St., New York, NY 10001.

April 9-12
Intergraphics '84, Sasakawa Memorial Hall, Tokyo, Japan. This conference and exposition is cosponsored by the Society of Manufacturing Engineers (SME) and the World Computer Graphics Association (WCGA). It will focus on the growing importance of computer graphics in business and manufacturing industries. For information, contact James McLaughlin, Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-0023.

April 13-14
The Fourteenth Annual Virginia Computer User's Conference, Sheraton Hotel, Blacksburg, VA. This conference is sponsored by the Virginia Tech Student Chapter of the ACM (Association for Computing Machinery) and the computer science department of Virginia Tech. Topics include modeling and simulation, STARS and

a message to our subscribers

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Japanese fifth-generation computers, and microcomputers. For information, contact Suzanne Nagy or Roger Goff, VCUC-14, 562 McBryde Hall, Virginia Tech, Blacksburg, VA 24061.

April 13–15

The International Personal Robotics Congress and Exposition, Convention Center, Albuquerque, NM. International corporations and high-technology executives can view the latest in robots designed to serve personal needs. For details, contact Albuquerque Convention and Visitors Bureau Inc., POB 26866, Albuquerque, NM 87125-6866, (505) 243-3696.

April 16–18

Videotex '84, Chicago, IL. The focus of this international conference and exhibition is commercial applications and activities of videotex. For details, contact Sally Summers, London Online Inc., Suite 1190, 2 Penn Plaza, New York, NY 10121, (212) 279-8890.

April 17–19

IPAD II, Marriott Hotel, Denver, CO. This is the second national symposium to promote a wider awareness of the technology surrounding the Integrated Program for Aerospace-vehicle Design (IPAD). The focus will be on advances in distributed database management technology to support integrated CAD/CAM requirements. It is sponsored by the National Aeronautics and Space Administration, the Department of the Navy, and the Industry Technical Advisory Board for IPAD. Information is available from the IPAD Project Office, Mail Stop 246, NASA Langley Research Center, Hampton, VA 23665, (804) 865-2888.

April 18–20

The 1984 Rocky Mountain Data Processing Expo & Conference, Denver, CO. This is the seventh annual expo sponsored by the Mile High Chapter of the Data Processing Management Association. Displays will include mini- and microcomputers, word processors, software, educational services, and network systems. It is being held in conjunction with the DPMA's Region 4 conference. For information, contact Industrial Presentations West Inc., Suite 304, 3090 South Jamaica Court, Aurora, CO 80014, (303) 696-6100.

April 24–25

Workspace 84, Moscone Center, San Francisco, CA. This second annual conference and exposition, sponsored by National Fairs Inc., will be devoted to the concerns of the automated office. For details, contact Charley Yourd, National Fairs Inc., 1902 Van Ness Ave., San Francisco, CA 94109.

April 26–28

Science Park '84, New Haven, CT. This microcomputer conference and exposition is designed for small-business executives. For details, contact Science Park '84, Five Science Park, New Haven, CT 06511, (203) 436-3089. ■

In order to gain optimal coverage of your organization's computer conferences, seminars, workshops, courses, etc., notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, POB 372, Hancock, NH 03449. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

Books Received

The Academic Apple, Richard Mowe. Reston, VA: Reston Publishing, 1983; 176 pages, 15.3 by 23 cm, softcover, ISBN 0-8359-0033-9, $10.95.

Advanced Database Machine Architecture, David K. Hsiao, ed. Englewood Cliffs, NJ: Prentice-Hall, 1983; 416 pages, 18.5 by 24.3 cm, hardcover, ISBN 0-13-011262-3, $35.

Apple II DiskGuide, Zelda Gifford. Berkeley, CA: Osborne/McGraw-Hill, 1983; 46 pages, 13.5 by 13.5 cm, spiral-bound, ISBN 0-931988-96-9, $7.95.

Atari 400/800 DiskGuide, John Taylor. Berkeley, CA: Osborne/McGraw-Hill, 1983; 64 pages, 13.5 by 13.5 cm, spiral-bound, ISBN 0-931988-95-0, $7.95.

Automating Your Financial Portfolio, Donald Woodwell. Homewood, IL: Dow Jones—Irwin, 1983; 272 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-87094-399-5, $19.95.

Automation, John Diebold. New York: American Management Associations Book Division, 1983; 224 pages, 14.5 by 21.3 cm, hardcover, ISBN 0-8144-5756-8, $14.95.

BASIC Subroutines for Commodore Computers, Eddie Adamis. New York: John Wiley & Sons, 1983; 320 pages, 17 by 25.3 cm, softcover, ISBN 0-471-86541-9, $12.95.

C-Bims: Cassette-Based Information Management System for the PET, Gary Greenberg. Blue Ridge Summit, PA: Tab Books, 1983; 224 pages, 13 by 21 cm, softcover, ISBN 0-8306-1489-3, $10.95.

The COBOL Programmer's Book of Rules, G. Ledin Jr., M. Kudlick, and V. Ledin. Belmont, CA: Lifetime Learning Publications, 1983; 240 pages, 15 by 23 cm, softcover, ISBN 0-534-97923-8, $14.95.

CP/M DiskGuide, Curtis A. Ingraham. Berkeley, CA: Osborne/McGraw-Hill, 1983; 40 pages, 13.5 by 13.5 cm, spiral-bound, ISBN 0-931988-97-7, $8.95.

CP/M for the IBM Using CP/M-86, Judi N. Fernandez and Ruth Ashley. New York: John Wiley & Sons, 1983; 272 pages, 17 by 25 cm, softcover, ISBN 0-471-89719-1, $14.95.

Commodore 64 User's Handbook, the WSI staff. Cleveland, OH: Weber Systems Inc., 1983; 312 pages, 13.5 by 21.5 cm, softcover, ISBN 0-938862-50-2, $14.95.

Computer Graphics for the IBM Personal Computer, Donald Hearn and M. Pauline Baker. Englewood Cliffs, NJ: Prentice-Hall, 1983; 352 pages, 18 by 24.5 cm, hardcover, ISBN 0-13-164335-5, $24.95.

Computers for Profit, David C. Dykstra. Reston, VA: Reston Publishing Co., 1983; 272 pages, 17.5 by 23.5 cm, softcover, ISBN 0-8359-0867-4, $14.95.

CONLAN Report, R. Piloty, M. Barbacci, D. Borrione, D. Dietmeyer, F. Hill, and P. Skelly. Lecture Notes in Computer Science, #151. New York: Springer-Verlag, 1983; 192 pages, 16.5 by 24.5 cm, softcover, ISBN 0-387-12275-3, $10.

Controlling Financial Performance, An APPLE Business User's Guide, D. P. Curtin, J. R. Alves, and A. K. Briggs. Somerville, MA: Curtin & London, 1983; 176 pages, 21.5 by 28 cm, softcover, ISBN 0-930764-58-7, $15.50.

Controlling Financial Performance, An IBM PC Business User's Guide, D. P. Curtin, J. R. Alves, and A. K. Briggs. Somerville, MA: Curtin & London, 1983; 176 pages, 21.5 by 28 cm, softcover, ISBN 0-930764-57-9, $15.50.

Cryptography, Thomas Beth, ed. Lecture Notes in Computer Science, #149. New York: Springer-Verlag, 1983; 416 pages, 16.5 by 24 cm, softcover, ISBN 0-387-11993-0, $18.50.

DBMS For Distributed Computers and Networks, Dimitris N. Chorafas. Princeton, NJ: Petrocelli Books, 1983; 272 pages, 16 by 24 cm, hardcover, ISBN 0-89433-184-1, $24.95.

The Design of Dynamic Data Structures, Mark H. Overmars. Lecture Notes in Computer Science, #156. New York: Springer-Verlag, 1983; 192 pages, 16.5 by 24 cm, softcover, ISBN 0-387-12330-X, $10.

The Design of Well-Structured and Correct Programs, Suad Alagić and Michael A. Arbib. New York: Springer-Verlag, 1978; 304 pages, 16.5 by 24 cm, hardcover, ISBN 0-387-90299-6, $17.

Direct Methods for Sparse Matrices, Ole Osterby and Zahari Zlatev. Lecture Notes in Computer Science, #157. New York: Springer-Verlag, 1983; 136 pages, 16.5 by 24.3 cm, softcover, ISBN 0-387-12676-7, $8.50.

Easy Add-On Projects for Spectrum, ZX81 & ACE, Owen Bishop. London, England: Bernard Babani Ltd., 1983; 192 pages, 11 by 17.8 cm, softcover, ISBN 0-85934-099-6, £2.75.

Effective Structured Programming, Lem O. Ejiogu. New York: Petrocelli Books, 1983; 192 pages, 16 by 24 cm, hardcover, ISBN 089433-205-8, $24.95.

Electro-Optical Communications Dictionary, Dennis Bodson and Dan Botez, eds. Rochelle Park, NJ: Hayden Book Co., 1983; 176 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-8104-0961-5, $16.95.

Electronics Handbook, Matthew Mandl. Reston, VA: Reston Publishing Co., 1983; 376 pages, 16 by 24 cm, hardcover, ISBN 0-8359-1603-0, $29.95.

40 Easy Steps to Programming in BASIC & Logo, James L. Poirot and R. Clark Adams. Austin, TX: Sterling Swift Publishing Co., 1983; 64 pages, 21.5 by 28 cm, softcover, ISBN 0-88408-275-X, $3.95.

44 Dynamic ZX-81 Games and Recreations, Ian Davies. Englewood Cliffs, NJ: Prentice-Hall, 1983; 174 pages, 15.3 by 22.8 cm, softcover, ISBN 0-13-329144-8, $19.95.

Foundations of Computation Theory, Marek Karpinski, ed. Lecture Notes in Computer Science, #158. New York: Springer-Verlag, 1983; 532 pages, 16.5 by 24.3 cm, softcover, ISBN 0-387-12689-9, $22.

Getting Started on the Sharp 1500 & Radio Shack PC-2, H. C. Pennington, Gary Camp, and Ralph Burns. Upland, CA: IJG Inc., 1983; 280 pages, 21 by 27.5 cm, ISBN 0-936200-11-1, $16.95.

Getting the Most Out of Your Word Processor, Arnold Rosen. Englewood Cliffs, NJ: Prentice-Hall, 1983; 222 pages, 17.3 by 23.5 cm, softcover, ISBN 0-13-354548-2, $9.95.

Graph-Grammars and Their Application to Computer Science, Hartmut Ehrig, Manfred Nagl, and Grzegorz Rozenberg, eds. Lecture Notes in Computer Science, #153. New York: Springer-Verlag, 1983; 464 pages, 16.6 by 24.3 cm, softcover, ISBN 0-387-12310-5, $20.50.

Guide to the IBM Personal Computer, Walter Sikonowiz. New York: BYTE Books/McGraw-Hill, 1983; 312 pages, 15.3 by 22.9 cm, softcover, ISBN 0-07-057484-7, $19.95.

Hardware Interfacing with the Apple II Plus, John E. Uffenbeck. Englewood Cliffs, NJ: Prentice-Hall, 1983; 256 pages, 18 by 24 cm, hardcover, ISBN 0-13-383851-X, $19.95.

How to Win at Video Games, the editors of *Consumer Guide.* New York: Crown Publishers, 1983; 64 pages, 21

by 27.5 cm, spiral-bound, ISBN 0-517-42470-3, $3.98.

I Speak BASIC to My VIC, (Teacher's Manual), Aubrey B. Jones Jr. Rochelle Park, NJ: Hayden Book Co., 1983; 272 pages, 21 by 28 cm, softcover, ISBN 0-8104-6169-2, $18.75.

IBM and the U.S. Data Processing Industry: An Economic History, Franklin M. Fisher, James W. McKie, and Richard B. Mancke. New York: Praeger Publishers, 1983; 544 pages, 16 by 24.3 cm, hardcover, ISBN 0-03-063059-2, $37.95.

IBM Data Files, David Miller. Reston, VA: Reston Publishing Co., 1983; 272 pages, 15.3 by 22.8 cm, softcover, ISBN 0-8359-3026-2, $15.

IBM PC DiskGuide, David A. Wilson. Berkeley, CA: Osborne/McGraw-Hill, 1983; 48 pages, 13.5 by 13.5 cm, spiral-bound, ISBN 0-931988-94-2, $8.95.

The IBM/PC & Business Software, James E. Kelley Jr. Wayne, PA: Banbury Books, 1983; 354 pages, 18 by 23.5 cm, spiral-bound, ISBN 0-88693-000-6, $39.95. Includes two 5¼-inch floppy disks.

The IBM Personal Computer, Robert J. Traister. Blue Ridge Summit, PA: Tab Books, 1983; 202 pages, 19.5 by 23.5 cm, softcover, ISBN 0-8306-1496-6, $10.95.

IC Timer Cookbook, 2nd ed. Walter G. Jung. Indianapolis, IN: Howard W. Sams & Co., 1983; 384 pages, 13 by 21 cm, softcover, ISBN 0-672-21932-8, $17.95.

Kaypro User's Handbook, the WSI staff. Cleveland, OH: Weber Systems Inc., 1983; 312 pages, 13.5 by 21.5 cm, softcover, ISBN 0-938862-12-X, $14.95.

The Master Memory Map for the Commodore 64, Paul Pavelko and Tim Kelly. Reston, VA: Reston Publishing Co., 1983; 192 pages, 15.3 by 22.5 cm, softcover, ISBN 0-8359-4243-6, $14.95.

Mastering Micros, Hannah I. Blank. New York: Petrocelli Books, 1983; 368 pages, 16 by 24 cm, hardcover, ISBN 0-89433-207-4, $24.95.

Microcomputer Graphics and Programming Techniques, Harry Katzan Jr. New York: Van Nostrand Reinhold, 1982; 244 pages, 16 by 23.3 cm, hardcover, ISBN 0-442-28419-5, $22.50.

Minute Manual for Apple Writer II, Jim Pirisino. Columbia, MD: Minuteware, 1983; 85 pages, 13.5 by 21.5 cm, softcover, ISBN 0-913131-00-8, $7.95.

Office Automation and Word Processing Fundamentals, Shirley A. Waterhouse. New York: Harper & Row, 1983; 368 pages, 18.7 by 23.4 cm, softcover, ISBN 0-06-046954-4, $14.50.

PC DOS Using the IBM PC Operating System, Ruth Ashley and Judi N. Fernandez. New York: John Wiley and Sons, 1983; 240 pages, 17 by 25 cm, softcover, ISBN 0-471-89718-3, $14.95.

Personal Computers & Games, the editors of *Consumer Guide*. New York: Crown Publishers, 1983; 64 pages, 21 by 27.5 cm, spiral-bound, ISBN 0-517-41595-X, $3.98.

Pictorial Data Analysis, R. M. Haralick, ed. New York: Springer-Verlag, 1983; 480 pages, 17 by 25 cm, hardcover, ISBN 0-387-12288-5, $49.70.

Planning and Budgeting, An APPLE Business User's Guide, J. R. Alves, D. P. Curtin, and A. K. Briggs. Somerville, MA: Curtin & London, 1983; 144 pages, 21.5 by 28 cm, softcover, ISBN 0-930764-62-5, $15.50.

Planning and Budgeting, An IBM PC Business User's Guide,

J. R. Alves, D. P. Curtin, and A. K. Briggs. Somerville, MA: Curtin & London, 1983; 144 pages, 21.5 by 28 cm, softcover, ISBN 0-930764-61-7, $15.50.

Polishing Your Apple, vol. 2, Herbert M. Honig. Indianapolis, IN: Howard W. Sams & Co., 1983; 112 pages, 14 by 21.5 cm, softcover, ISBN 0-672-22160-8, $4.95.

Problem Solving and Structured Programming with Fortran 77, Martin O. Holoien and Ali Behforooz. Monterey, CA: Brooks/Cole Publishing Co., 1983; 528 pages, 18.5 by 23.5 cm, softcover, ISBN 0-534-01275-2, $21.95.

The Programmer's CP/M Handbook, Andy Johnson-Laird. Berkeley, CA: Osborne/McGraw-Hill, 1983; 512 pages, 18.5 by 23.5 cm, softcover, ISBN 0-88134-103-7, $21.95.

The Programmer's Craft, Richard J. Weiland. Reston, VA: Reston Publishing Co., 1983; 176 pages, 18 by 24 cm, hardcover, ISBN 0-8359-5645-8, $18.95.

Programmer Productivity, Myths, Methods, and Murphology, Lowell Jay Arthur. New York: John Wiley & Sons, 1983; 314 pages, 16 by 24 cm, hardcover, ISBN 0-471-86434-X, $22.95.

Programming a Personal Computer, Per Brinch Hansen. Englewood Cliffs, NJ: Prentice-Hall, 1983; 440 pages, 18 by 24.5 cm, hardcover, ISBN 0-13-730267-3, $25.

The Programming Languages, C. H. Smedema, P. Medema, and M. Boasson. Englewood Cliffs, NJ: Prentice-Hall International, 1983; 160 pages, 15 by 23 cm, softcover, ISBN 0-13-729756-4, $16.95.

The Programming Language Ada Reference Manual, ANSI/MIL-STD-1815-1983. Lecture Notes in Computer Science, #155. New York: Springer-Verlag, 1983; 344 pages, 16.5 by 24 cm, softcover, ISBN 0-387-12328-8, $14.50.

Programming Languages, Design and Implementation, 2nd ed. Terrence W. Pratt. Englewood Cliffs, NJ: Prentice-Hall, 1984; 624 pages, 18.5 by 24 cm, hardcover, ISBN 0-13-730580-X, $24.95.

Programming the Apple II in BASIC, Paul Tebbe. Englewood Cliffs, NJ: Prentice-Hall, 1983; 192 pages, 15.3 by 22.8 cm, softcover, ISBN 0-13-729749-1, $16.95.

Quadpack, A Subroutine Package for Automatic Integration, R. Piessens, E. de Doncker-Kapenga, C. W. Überhuber, and D. K. Kahaner. New York: Springer-Verlag, 1983; 312 pages, 15.5 by 23 cm, softcover, ISBN 0-387-12553-1, $22.

Semiconductor Device Technology, Malcolm E. Goodge. Indianapolis, IN: Howard W. Sams & Co., 1983; 512 pages, 16.3 by 24.3 cm, hardcover, ISBN 0-672-22074-1, $34.95.

Simulation of Computer Communication Systems, Charles H. Sauer and Edward A. MacNair. Englewood Cliffs, NJ: Prentice-Hall, 1983; 174 pages, 18.3 by 24.3 cm, hardcover, ISBN 0-13-811125-1, $25.

Software Design and Development, Philip Gilbert. Chicago, IL: Science Research Associates, 1983; 704 pages, 19 by 24.5 cm, hardcover, ISBN 0-574-21430-5, $32.

Software Directory, 7th ed. Fairfax, VA: PC Clearinghouse, 1983; 840 pages, 21.5 by 27.5 cm, softcover, ISBN 0-88674-000-2, $29.95.

The Structured Alternative: Program Design, Style, and Debugging, Don Cassel. Reston, VA: Reston Publishing Co., 1983; 256 pages, 16 by 23.5 cm, hardcover, ISBN 0-8359-7084-1, $24.95.

Structured Cobol Report Writer, David Schechter and George Yvkoff. Reston, VA: Reston Publishing Co., 1982; 320 pages, 18.3 by 24.3 cm, hardcover, ISBN 0-8359-7097-3, $24.95.

25 Advanced Games for the PET/CBM, Larry Hatch. Reston, VA: Reston Publishing Co., 1983; 224 pages, 15 by 23 cm, softcover, ISBN 0-8359-7894-X, $12.95.

The User's Guide to Commodore 64 & VIC 20 Computers, Software & Peripherals, the editors of *Consumer Guide.* New York: Crown Publishers, 1983; 80 pages, 21 by 27.5 cm, spiral-bound, ISBN 0-517-41447-3, $4.98.

User's Handbook to the Atari 400/800 Computers, Jeffrey R. Weber and Stephen J. Szczecinski. Cleveland, OH: Weber Systems Inc., 1983; 322 pages, 13 by 21.5 cm, softcover, ISBN 0-938862-15-4, $13.95.

User's Handbook to the IBM Personal Computer, Jeffrey R. Weber. Cleveland, OH: Weber Systems Inc., 1982; 300 pages, 21.5 by 13.8 cm, softcover, ISBN 0-938862-13-8, $13.95.

User's Handbook to the TRS-80 Model II Computer, Jeffrey R. Weber. Cleveland, OH: Weber Systems Inc., 1983; 304 pages, 13 by 21.5 cm, softcover, ISBN 0-938862-01-4, $13.95.

User's Handbook to the VIC-20 Computer, Jeffrey R. Weber and Stephen J. Szczecinski. Cleveland, OH: Weber Systems Inc., 1983; 280 pages, 13.3 by 21.5 cm, softcover, ISBN 0-938862-48-0, $13.95.

Using VisiCalc, Carol Klitzner and Matthew J. Plociak Jr. New York: John Wiley & Sons, 1983; 277 pages, 17 by 25 cm, softcover, ISBN 0-471-89852-X, $16.95.

VIC BASIC, A User-Friendly Guide, Ramon Zamora, Don Inman, Bob Albrecht, and Dymax. Reston, VA: Reston Publishing Co., 1983; 360 pages, 15 by 23 cm, softcover, ISBN 0-8359-8377-3, $14.95.

Visicalc DiskGuide, David A. Wilson, Berkeley, CA: Osborne/McGraw-Hill, 1983; 16 pages, 13.5 by 13.5 cm, spiral-bound, ISBN 0-931988-98-5, $6.95.

A Z80 Workshop Manual, E. A. Parr. London, England: Bernard Babani Ltd., 1983; 192 pages, 11 by 18 cm, softcover, ISBN 0-85934-087-2, £2.75.■

This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

The answer to the cryptogram on page 386 reads:

SOME CONSIDER IT FOOLISH TO WORK THESE PUZZLES, WHILE OTHERS PREFER ANAGRAMS AND CROSSWORDS. I LIKE THEM ALL AND HOPE THAT YOU HAD SOME FUN WITH THIS EASY ONE.

BYTE's Bugs

Gremlins Tiptoed Here

Author Raymond A. Diedrichs wrote in to say that Gremlins had tiptoed through the version of his Font program ("A Character Editor for the IBM PC," November, page 467). The following patches should be made in the indicated program lines:

line 2090 "I + 1" instead of "I"
line 2175 "CROW + 1" instead of "CROW"
line 2280 "1 TO 8" instead of "0 TO 7"
line 2325 "1 TO 8" instead of "0 TO 7"■

Clubs and Newsletters

Scope for Scholars

Scope (Scholarly Communications: Online Publishing and Education) is a newsletter that is produced bimonthly at Queens College in Flushing, New York, and contains information on networks, publishing opportunities, calls for papers, a calendar, and annotated bibliographies. An annual subscription is $47. For details, write to *Scope*, Queens College, City University of New York, Flushing, NY 11367-0904.

A Word for IBM PC Users

The Washtenaw IBM Personal Computer User Society (WIPCUS) meets on the third Thursday of every month in Ann Arbor, Michigan. The monthly publication, *WIPCUS Word*, contains minutes of meetings, information of sources for the IBM Personal Computer, and a list of recent acquisitions in the WIPCUS disk library. The club also maintains a hotline and an electronic bulletin board system, the WIPCUS Wire, that operates 24 hours a day on the three commonly used modem protocols. Membership is $18 a year; $12 for students and senior citizens. Address all correspondence to Sue Wooley, WIPCUS, 2647 Yost, Ann Arbor, MI 48104.

Innovations in Education

Hands On is a quarterly newsletter produced by Technical Education Research Centers (TERC), a nonprofit, public service corporation dedicated to improving education by encouraging the appropriate use of microcomputers in labs and classrooms. Each issue includes articles, book and software reviews, a bulletin board, news, and an idea exchange. A $10 contribution is requested to receive the quarterly newsletter. For information, contact Technical Education Research Centers Inc., 8 Eliot St., Cambridge, MA 02138.

Computer Assistance for the Disabled

The Center for Computer Assistance to the Disabled (C-CAD) is a nonprofit corporation that meets regularly to discuss how the discovery of computers has contributed to the quadriplegic businessperson. Meetings also include demonstrations of Logo, adaptive software, voice recognition, and more. For details, write to C-CAD, POB 314, Hurst, TX 76053.

A Students' Scroll

Scroll, a newsletter prepared by students in the technical-writing program at Middlesex Community College in Massachusetts, contains information about career objectives and skills that potential technical writers will need to develop. For further details, write to the Technical Writing Program, Middlesex Community College, Springs Rd., Bedford, MA 01730, or call Caryl Dundorf at (617) 275-8910, ext. 278.

Guide to Periodicals

The Computer Newsletter, a guide to microcomputer information, is produced ten times a year in six editions for various brands of computers available today. Each issue contains a directory of recent articles from more than 50 periodical publications. References are annotated to include relevant source information. One subscription is $17.50 for all ten issues; when subscribing, include the name and model of your computer. Contact MHN Services Inc., Department M3, POB 952, Cleveland, OH 44120.

Compupro Across the Board

A national nonprofit users group for owners of Godbout's Compupro provides a forum in which to share technical information, solutions, and special-purpose applications. A monthly newsletter, a bulletin board system, and a member-list publication are planned. An optional charter membership is available for $10. To inquire or join, send your name, address, and equipment information to CPro Users Group, POB 1474, Woodbridge, VA 22193.

Newsletter for Productive Lawyers

The Automated Law Office Consultant is a newsletter that provides lawyers with information and analyses about automated-office products and how to select equipment that will improve productivity in the law office. A subscription is $65 a year from Roadrunner Publications Inc., POB 13548, Austin, TX 78711.

IBM Users in Bluegrass Country

The Bluegrass IBM PC Users Group meets on the fourth Saturday of every month at 1 p.m. in the University of Kentucky Computing Center's Micro Lab (Room 107, McVey Hall). Membership is $5 a year and includes a monthly newsletter and access to a software library. For further information, write to Diane Skoll, Room 72, McVey Hall, University of Kentucky, Lexington, KY 40506-0045.

For Genealogical Researchers

The Quinsept User Group produces a newsletter that covers such topics as genealogical-book reviews, problem solutions, and articles of interest to genealogical researchers. The newsletter will begin as a quarterly and progress into a bimonthly publication. Membership is $15 annually and includes a subscription to the newsletter. To apply for membership, write to Quinsept User Group, 5855 Santa Teresa Blvd., San Jose, CA 95123.

Oregonian Commodorians

The Southern Oregon Users Group meets twice a month to discuss the best uses for the Commodore 64 and VIC-20 computers. A newsletter is planned and anyone with ideas or suggestions is encouraged to send them to Jim Powell, 3600 Madrona Lane, Medford, OR 97501, (503) 779-7631.

A Capital Idea

The Capital Osborne Users Group (CAPOUG) meets once a month at the library in Bethesda, Maryland, to serve users from Maryland, northern Virginia, and the District

of Columbia. A $12 membership fee includes access to the software library maintained by the club and a subscription to the newsletter that contains articles, tutorials, and advertisements. For details, write to Merrill Hessel, 6200 Winnebago Rd., Bethesda, MD 20816.

Math and Science Education Journal

The Association of Computers in Mathematics and Science Teaching (ACMST), a nonprofit organization, produces a substantive quarterly publication called *The Journal of Computers in Mathematics and Science Teaching (JCMST)*. It is applicable to elementary, secondary, and college educators who would benefit from extensive features, reviews, resources, and a calendar. Members can benefit from the group's Computer Book Center, in which more than a dozen participating publishers of computer books provide reduced rates. Membership in ACMST is $15 a year and includes a subscription to the quarterly *JCMST*. Author's guidelines and advertising rates are available upon request. For further details, write to *The Journal of Computers in Mathematics and Science*, POB 4455, Austin, TX 78765.

Ataris are OK in Duncan

The Duncan Area Atari Computer Users Group (DAACUG) welcomes everyone interested in computing with Ataris to attend their monthly meetings in southwestern Oklahoma. Separate sessions for novice and experienced users are held after each general meeting. Annual membership dues are $10 and include access to the club's disk library and discounts on hardware and software purchases. For further details, contact John Borchardt, DAACUG, 911 Primrose St., Duncan, OK 73533.

A Band of Colors

The Vancouver Color Computer Club meets at 7:30 p.m. on the third Tuesday of every month in Burnaby, British Columbia. To develop as broad a base as possible, everyone interested in the TRS-80 Color Computer is welcome to join. The $15 annual membership entitles you to participate in group purchases, the software library, hardware lending, and voting in the club. For details, contact the Vancouver Color Computer Club, 333 Boyne St., New Westminster, British Columbia V3M 5J9, Canada.

ABACOS By the Bunch

A Bunch of Atari Computer Owners (ABACOS) has formed in the Saugerties area of New York state to serve the users who live between Albany and New York City. A newsletter, *Refresh*, is produced every two months and contains software reviews, an editorial, and a program of the month. A $4 annual membership includes a subscription to the newsletter. For details, contact ABACOS, 90-A Partition St., Saugerties, NY 12477, (914) 246-7193.

News for Epson Users

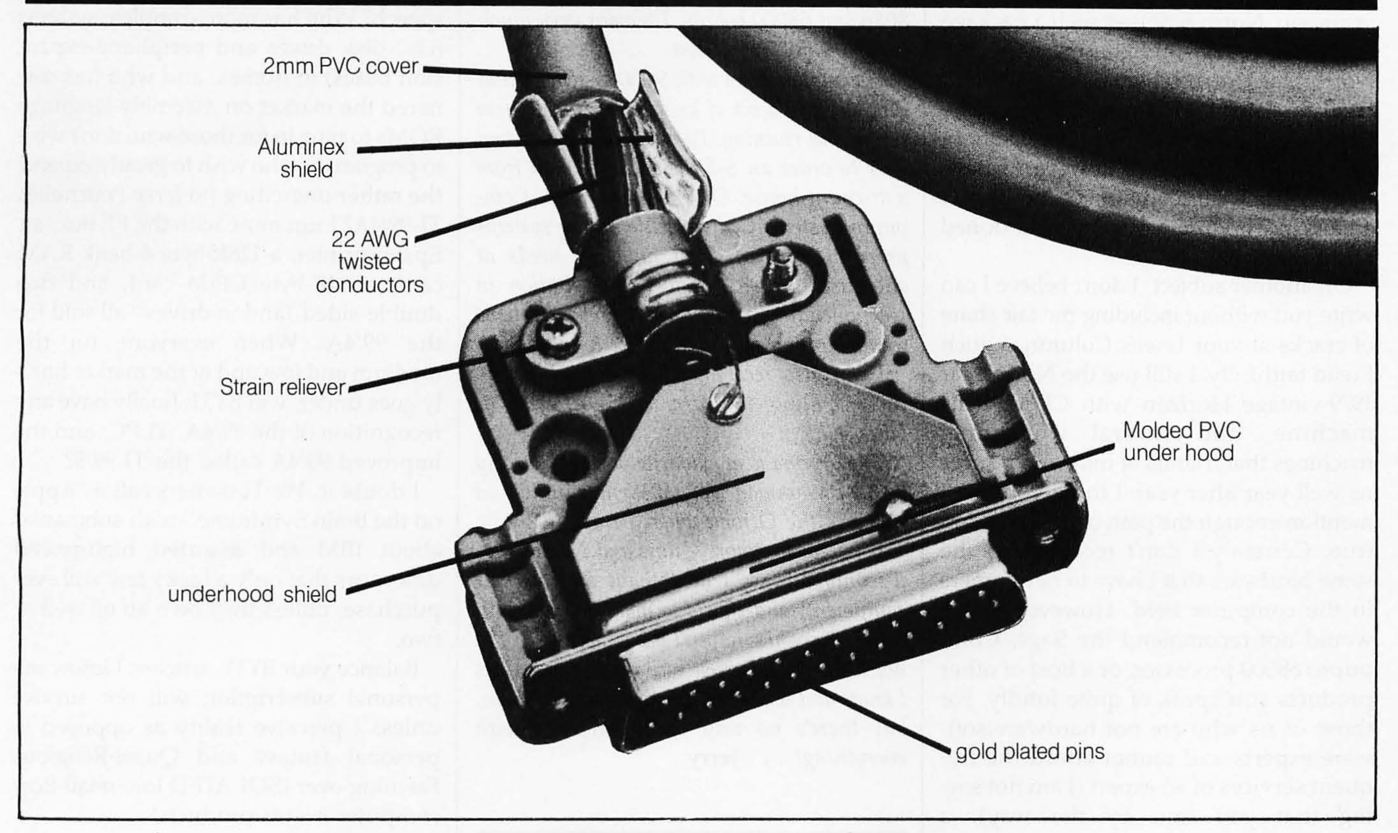
QHX, an independent newsletter for users of the Epson QX-10 and HX-20 computers, is produced every month by the Epson Computing Group. Readers are welcome to submit questions, hints, or articles about new products to *QHX* for publication. The number of the free, club-maintained, active electronic bulletin board is (618) 997-3220. A one-year subscription to the newsletter is $25. For further details, contact the Epson Computing Group, 400-2 East DeYoung, Marion, IL 62959, (618) 993-3600.

Forum for Data

The Data Forum is a user-oriented and -operated information exchange free to users who apply via the communications line. The database has plans to expand with user input. For information, contact Stephan Anderson, Suite 718, 20993 Foothill Blvd., Hayward, CA 94541, or call (415) 276-6322. ■

If you would like BYTE readers to know about your club or newsletter send the details accompanied by no more than one newsletter to Clubs and Newsletters, BYTE Publications, POB 372, Hancock, NH 03449. Overseas groups are encouraged to participate. Please allow at least three months for your announcement to appear.

ANNOUNCING THE INSIDE STORY ON DATA SPEC™ CABLES.



Take a look at the picture above. The shielding under the RS232 connector hood of DATA SPEC™ cables is different from anything you've seen before. No flimsy foil. Or painted hood. Instead, DATA SPEC™ gives you an extra heavy gauge shield under the normal hood which ensures that the cables exceeds the FCC requirements on emission standards.

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DATA SPEC™ cables. There's more to it than meets the eye.

*PDT (Poly-vinyl doping technique) involves the injection of poly-vinyl under the shield to fuse the conductors and pins together, thus ensuring reliability under the most adverse conditions. PDT is a registered trademark of Advanced Tool Technology Inc.

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Circle 396 for End-User inquiries.

BYTE's User to User

Conducted by Jerry Pournelle

Tried and True

Dear Jerry,

You stated in "Epson QX-10, Zenith Z-29, CP/M-68K, and More" (August, page 434) that you are interested in the UCSD p-System, especially under the CP/M operating system. A number of years ago, North Star had such a package available. It was purchased with the North Star Horizon I am using (1979 vintage) and runs fairly smoothly. I am quite intrigued by the concepts it presents in program development; however, I have had so much difficulty in getting its text editors to work properly that I abandoned the project.

On another subject, I don't believe I can write you without including my fair share of cracks at your User's Column, which I read faithfully. I still use the North Star 1979-vintage Horizon with CP/M. This machine, and several workhorse machines that friends of mine own, serve us well year after year. I think you don't mention enough the path of the tried and true. Certainly I don't recommend the same hardware that I have to newcomers in the computer field. However, I also would not recommend the Sage, Compupro 68000 processor, or a host of other products you speak of quite fondly. For those of us who are not hardware/software experts and cannot afford the frequent services of an expert (I am not saying that you can, by the way), a somewhat less exotic, but time-tested, machine is the better buy.

Lastly, I will make these off-the-cuff comments. You don't seem to give adequate press to North Star, Qume, and a host of other equipment. Also, the S-100 bus seems to have fallen out of favor with you. Need I cite the Epson, Otrona, Sage, and possibly more? I don't know about you, but as I look for a computer to supplement the services of my North Star, I am glad that I have a bus ready to plug new boards into. Any computer that I purchase in the next few years will certainly be an S-100 machine.

Paul Kile
Appleton, WI

My late mad friend also gave up on the UCSD Pascal editors, which caused him to scrap public-domain UCSD Pascal. I gather that Softech has made considerable improvements, but I haven't seen its UCSD Pascal for S-100 machines.

I don't know where you get the impression that S-100 systems have fallen out of my favor. I'm writing this on a Compupro Z80, our workhorse machine is a Compupro 8085/8088 Dual Processor, and our major experimental machine is a Compupro that we use to test 8086 and 68000 boards. I remain very much an S-100 bus enthusiast.

The only problem with S-100 systems is that they do take a bit of knowledge to get them set up and running. I'd never advise a casual user to order an S-100 system by mail from a discount house. On the other hand, Compupro Systems Centers sell working systems properly configured for anyone's needs at advertised prices. I have no hesitation in recommending a Compupro from a Systems Center to any user, no matter how naive.

I can also recommend Sage machines to those willing to learn UCSD Pascal or CP/M-68K.

The Otrona is my favorite portable, largely because Workman has got Write running on it; I use the Otrona when I travel.

If I seem to ignore Qume and North Star, it's only because I don't have any of their equipment, and efforts to make contact with those companies haven't been successful. I'm not a theorist: I must write about machines I know and use. I try to look at a lot of them, but there's no way I can keep up with everything! . . . **Jerry**

Fawning Sci-Fi Writers

Dear Jerry,

I enclose an article whose headline reads: Osborne Ceases Production: Furloughs Most Workers. It makes your pro-Osborne article ("The Next Five Years in Microcomputers," September, page 233) a bit less fawning.

Having read your gushing article, I have only one observation. Where is Texas Instruments? When Apple and IBM finish their latest round of court cases against Franklin, its copycat-clone ACE, and the Taiwan/Japanese stolen-technology copycats, all the unlucky owners of those clones of Apple and IBM will be orphans without any company support! A corollary is that very little will be left in the professional market except TI PC (Pegasus)—very carefully ignored by BYTE—IBM PC, Apple, TI-99/4A, TI-99/8, and Commodore 64. Certainly Mattel will fold, then Apple and Commodore will founder. What we are watching is the sinking of the first wave of innovators and the survival of the fittest, regardless of fawning by science-fiction writers who should know better. Who sold the first mass-market 16-bit microprocessor with speech? Who has more complete systems (i.e., disk drives and peripheral-expansion boxes) in homes, and who has cornered the market on assembly-language ROMs to plug in for those who don't wish to program or who wish to greatly expand the rather unexciting (to Jerry Pournelle) TI-99/4A? I run mine with the PE Box, an Epson printer, a 128K-byte 4-bank RAM card, a 64K-byte CP/M card, and two double-sided Tandon drives—all sold for the 99/4A. When everyone on the medium and low end of the market finally goes under, will BYTE finally have any recognition of the 99/4A, TI PC, and the improved 99/4A called the TI-99/8?

I doubt it. We TI owners call it "Apple on the Brain Syndrome," with submanias about IBM and assorted high-priced dinosaurs that only a lucky few will ever purchase, unless they own an oil well or two.

Balance your BYTE articles! I know my personal subscription will not survive unless I perceive reality as opposed to personal fantasy and Quasi-Religious Fawning over ISOLATED low-retail-flow computer events/products!

R. Castleton
Richardson, TX

Gee, I never knew what my problem was.

Castleton reads different versions of both BYTE and the daily papers than I do; I thought we'd done a fair job of talking about TI equipment; also that there was some problem with the TI-99/4A's profitability.

No one more eagerly awaited the TI-99 than I did, and no one was more disappointed when we discovered that TI wasn't interested in publishing anything about its internal details. When you deliberately cut yourself off from the hobbyist world, you forfeit very little potential market—but you do forfeit an important source of software.

I think Adam Osborne did a lot for this field, and his low-cost all-up machine complete with software and documents was one of the crucial events in micro history. If that be fawning, make the most of it. . . . **Jerry**

Magazines and Advertisements

Dear Jerry,

Screenwriter II *can* be copied. I used Locksmith 4.0 on my copy and can *usually* load the copy. Sometimes the program load fails, but the failure is not totally catastrophic, that is, it returns to the menu after considerable disk grinding. Then it loads the program on the second try. Slightly less than totally satisfactory, but it does preserve the original disk for future use. These days, with Wordstar on another machine, the 40-column Apple screen usually drives me away.

In October's User to User (page 540), Mr. Henkin may be having trouble with an added feature of Screenwriter. After trying it on several Apples at my local dealer, I have come to the conclusion that trying to use the joystick option causes the total failure to boot. I don't know what the problem is, but I have never been able to boot the optioned Screenwriter with the joystick option enabled. Leave out that one option, and it does work.

The function of character search within a displayed line was deleted between Superscribe and Screenwriter. I missed that feature when I made the change. And Screenwriter uses the disks in an odd manner that is not quite convenient and I think would be bothersome for anyone not fully oriented to making obstinate hardware work like your "late mad friend" and me.

I was attracted to Calcstar by its similarity in command structure to Wordstar. Last week I placed an order with a BYTE advertiser; last evening the brown truck delivered the box (not COD as ordered). I went through the instruction manual, installing a copy of Calcstar, doing the exercises, and then tried to set up a time card for my work.

While I found that I could set up some sort of a time card to take in hours' and minutes' beginning and ending times and to compute total elapsed time, I have been unable to accomplish anything that resembles proper numerical computation. Like IBM FORTRAN, Calcstar uses binary floating point that even with 14 significant digits shows some approximation errors. Then Calcstar column formats only truncate the display, not the stored data. So I took a column of start and end times, computed elapsed times, totaled elapsed times, and then tried to round to the nearest 0.1 hour (a fetish of mine on customers' bills), and multiplied the result by my hourly rate. The result? The charge shown in the next cell did not match the calculator multiplication of the displayed data. That's not a good way to give the clients confidence in your arithmetic prowess when dealing in engineering services! Conclusion: Calcstar is inherently too badly constructed to be called a spreadsheet.

So, the next step is to send it back to the store and hope that some other spreadsheet functions better (as some of the reviews and books on spreadsheet programs do declare), right? Nope, wrong. The advertiser said, "It does like the book says, then it is not defective and we won't take it back. You should have spent full retail if you wanted to try the product first." And, "Since we failed to send it COD, it hasn't been paid for; we will be sending you an invoice."

I use CP/M partly not to have to worry about protection schemes that promise to prevent using programs for gainful purposes, and to have access to good programs. Now I have wasted a half day or more and have spent money without gaining a useful program, and the seller of the product refuses to take it back under any conditions. Is this the way BYTE magazine wishes to treat its readers?

Gerald N. Johnson, P.E.
Ames, Iowa

Few copy-protection schemes work for long; what one can do, another can undo. The real trouble is that the copy-protection attempt makes the software fragile. After all, the idea of copy protection is to make it difficult for the machine to read the disk—which may be a good idea for the vendor, but it's hardly what the user wants!

Many spreadsheet programs have limited precision; it's a feature one must check very carefully.

I'd like it if every mail-order house had a money-back guarantee, but some of the discount outfits operate at such a low markup that they simply can't do it. In general: the lower the price, the less support you can expect from the dealer.

Alas, you have the wrong idea about magazines and advertisements. The advertising department doesn't tell me what to write, and I don't tell them what ads to accept. Indeed, as long as advertisers pay their bills, it's legally very difficult to reject an ad, even if the magazine doesn't want to take it. We had one item that generated lots of angry letters, but legal advisors said we couldn't reject the outfit's ad! Fortunately, they got in a snit about one of my reviews and cancelled, causing joy among those who had to open and file all the hate mail. . . . **Jerry**

Assembly-Language No-Man's Land

Dear Jerry,

I greatly enjoy your User's Column in BYTE. Keep up the struggle for better documentation! It is partly in that regard that I am writing to you. Perhaps you can recommend some books or articles that deal with an area that is not often addressed.

Texts on assembly-language programming invariably assume either that the reader knows all about it and only wants the details of some new processor (including hardware considerations that the programmer doesn't necessarily need) or that the reader knows nothing and must be told about number bases, etc. They then lead into the writing of whole programs, systems, monitors, etc. Texts on high-level languages work in much the same way. Two sorts are available: references that define syntax with railroad diagrams and introductory texts that have to explain about the meaning of arithmetic assignment statements and such.

A no-man's land exists between these two extremes that interests me. Specifically, how do I use assembly language to write the critical subroutine that determines program efficiency and link it into the main program that is written in FORTRAN-80, compiled MBASIC, or whatever? I have purchased Microsoft F-80 (subset FORTRAN-IV), L-80 (Linker), M-80 (Macro-assembler), and MBASIC compiler in order to do such things. A recent article in BYTE ("Chisel Your Code with a Profiler," August, page 286) described ways to conduct activity analysis to identify the 10 percent of the code that does 90 percent of the work. But it (as with most books and documentation) says only to use assembly code to optimize that 10 percent.

I know how to identify the critical subroutine. In a recent research project (a new numerical neutron-transport scheme), most of the code is input of the problem parameters, initialization of arrays, analysis of results, and printout. This all executes once per run. But one

subroutine is called 294,912 times in a typical run. The program runs four hours on a 5-MHz 8088/8087 system.

The documentation (and the advertising) indicates that F-80, L-80, Lib-80, M-80, and MBASIC compiler constitute a "software development system" and that FORTRAN and assembly-language routines can be called from BASIC programs, etc. However, all the manuals point to each other as containing the details, and I have not successfully managed to use this software for its intended purpose. (When I called Microsoft Tech Support for details, the response was "Just try it. It all works." I found this less than helpful, but I tried it. The result: error messages. In particular, it seems that the FORTRAN subroutine requires that the Forlib library be linked to define various global symbols. The main program similarly requires that Obslib be linked or the run-time system used. I prefer stand-alone code. However, linking both libraries results in "multiply defined global symbol" errors, and the programs don't run. If you fail to link either library, you get "undefined global symbol" errors.

These tools were expensive, and it burns me not to be able to use them. So my question is: where do I find a text that will walk through some examples of actually using assembly code to optimize a routine for a program written in a high-level language?

Kirk Mathews
Springboro, OH

Good question. I wish I had such a book myself. There are Z80-code cookbooks and plenty of books on how to write the assembly-language programs, but darned little showing you precisely how to link in assembly programs to previously written stuff.

I've found the same kind of problem with CB-80 and Digital Research's RMAC assembler; it ought to be easy to do that kind of thing, but there are insufficient examples to let me puzzle it out.

Maybe one or another of the readers can help? . . . **Jerry**

Benchmark Marks

Dear Jerry,

Below are listed three variations of your 20 by 20 array benchmark, adapted to run in BASIC09 under the OS9 operating system on a 6809 card in an Apple II. BASIC09 compiles to an intermediate code that is then interpreted and is thus directly comparable to CBASIC in that respect.

Benchmark Variation	Time (min:sec)
Integer Arrays, Integer Loop Indexes	00:31
Real Arrays, Real Loop Indexes	01:11
Real Arrays, Integer Loop Indexes	00:45

In comparison with your published figures (October 1982 BYTE, page 262) for other processor/language combinations the times would seem to be extremely good, especially when you consider that the 6809 is running at the Apple's nominal clock speed of 1.023 MHz. I don't think you've published figures for this particular combination. Please notice that a 68000 processor runs p-code almost as fast as an 8086 runs its machine language. If it weren't so popular, the 8086 and its 8088 cousin would be good jokes. I've never been able to understand why anybody would transplant 8-bit architecture to a 16-bit processor.

Frank C. Kuechmann
Vancouver, WA

You and my son agree on the 68000 as a better way to go, but a number of people I respect prefer the 8086 (followed by the 286, etc.). As for me, I'm not so interested in chip architecture or in assembly languages. As the machines get fast enough and memory falls in price, most real programming will be done in higher-level languages.

We at Chaos Manor are doing most of our work in Pascal just now, with the intention of switching to Modula-2 as soon as we have stable Modula compilers. Our programs are portable between the Sage and the Godbout 8086, and we expect to be able to recompile them and run on more advanced systems as they come out. . . . **Jerry**

Transmitting Pages

Dear Jerry,

As a fellow H/Z-19 terminal owner, can you tell me who knows the special routine to make the "Transmit Page" (ESC #) function work? See enclosure. Two letters to Heath have drawn blanks.

Peter Engh
La Jolla, CA

As your enclosure shows, the Heath documentation (page 23) discusses "Transmit Page" but refers to the possibility of special routines in the host computer. In big machines, you can edit material on the terminal and, when the screen is set up the way you want, send the whole page at once. This is useful for time-sharing systems because you're not using central-computer time while editing.

I know of few microcomputers that operate in the transmit-page mode. If you want to save stuff from the Z-19 screen, you'll have to write a special routine. The Z-19 manual describes what the terminal pitches; you have to write the catcher. . . . **Jerry**

Copyrighting and Personalizing

Dear Jerry,

In the August 1983 issue of *PC Magazine* (page 58) under the Letters banner "Legal Matter," the secretary of Cincinnati's IBM PC User's group requests clarification of the legality of distribution of software copied from the pages of *PC Magazine*. I can't believe *PC's* response, which I quote: "The contents of each issue of *PC Magazine* are copyrighted by the publisher, and all rights of reproduction in all forms and media are strictly reserved. The original purchaser/subscriber only is authorized to make copies solely for his/her own use. Distribution, transmission, or transfer of copies to any other person is an infringement of the copyright. —Ed." To your knowledge, is this an industry standard?

On to other things. Seems to me that a partial solution of the software-piracy conflict is to personalize each product. That is, include in each screen the name of the purchaser. Pirates would be easier to spot and would have to suffer at least some embarrassment to be blatantly using a product that was licensed to someone else. Sure it complicates manufacture and it could be defeated on a case-by-case basis by clever counter-programming, but it is a thought. (If the retail vendor had to run a purchaser-specific customization procedure at the store, then at least it would guarantee the machine readability of the disks you purchase.) It would be irritating to be constantly reminded that a program you were using often was illicitly copied from another user whose name you are frequently reminded of.

I use Compuview's Vedit on an Osborne 1 and am pleased with it. (This machine can perform string searches so much faster than any larger machine I've ever used that I'm continually amazed.) I'm glad to hear that the customization process will be simplified. I like Compuview's software-update subscription option ($50 per year for Vedit).

Larry Weiss
Garland, TX

Actually, PC's statement is just an explanation of the copyright laws. Only the copyright holder has the right to sell or distribute copies of copyrighted matter. There is no restriction on resale of the original material; it's legal for me to sell or lend used books. However, I may not make copies of them (except as provided under the "fair use" provisions of the Copyright Act). Specifically, I can't make a copy, then sell the original.

Magazines traditionally buy various packages of rights (the right to publish in magazines, the exclusive or nonexclusive right to include the article in anthologies, and so on); what's bought varies from magazine to magazine and often from author to author within the magazine.

Personalizing software is costly; imagine what it would cost to imprint the purchaser's name on each book sold by B. Dalton!

We're also pleased with Vedit for programming, although the number of commands can be overwhelming when you first try it. . . . **Jerry**

Wordstar Spelling Checker

Dear Jerry,

I recently discovered a useful way of using The Word Plus spelling checker with Wordstar. Instead of having The Word Plus mark the words you choose with asterisks or similar characters, I use a null character, CTRL @, as the marking character. There are several advantages to this.

First, if you forget to remove a mark before printing, at least you don't call attention to the mistake—useful if you only have time to print one copy of whatever you are working on.

Second, you can use some of the Spellstar options of Wordstar, e.g., you can find the marks that you have placed by typing CTRL-QL. This has the advantage that it doesn't destroy any other searches you have previously set up by using CTRL-QA or CTRL-QF, and it remembers changes that you have already made. So if you tell it to ignore a mark you placed, when it "sees" the same word again, it removes the mark from that and continues automatically.

Third, any words you tell Wordstar to put in dictionaries or ignore are recorded in a file called filename.ADD, which you can later edit and turn into a special dictionary for The Word. (You must edit the file first—Wordstar adds I, D, or S to the front of the word.)

By the way, I just read the book you wrote with Larry Niven, *Oath of Fealty*. I particularly chuckled over the part where the police have asked MILLIE for all the files in Rand's directory and MILLIE is told to print them at 300 baud. I trust that this was your idea.

Miles Thomas
Franklin Lakes, NJ

Thanks for the kind words, and also for the tip. We tried it on the Z-100 Wordstar and it worked fine.

Larry and I usually won't answer questions about who wrote what in our books, but given his public disclaimer on computer knowledge, I suppose I can admit that MILLIE was mostly my idea. . . . **Jerry**

Z-DOS and MS-DOS

Dear Jerry,

Your brief note in "Eagles, Text Editors, New Compilers, and Much More" (September, page 307) about the incompatibility problem between IBM PC programs and the Zenith Z-100 was moderately helpful. It could have been more so if Victor Wright's address in Louisville, Kentucky, had been included.

Your mention earlier in the column of your own Z-100 prompts me to ask you for any assistance and/or advice you can give in regard to "standard" program availability for the Z-DOS implementation of MS-DOS.

Gerald Erskine
New Brunswick, Canada

It's been my general policy not to include people's private addresses. Alas, I don't keep answered mail (much to the relief of my wife, housekeeper, and assistants; where would they put it?), so I can't look it up for you.

BUSS ("The Independent Newsletter of Heath Co. Computers," 716 E St. SE, Washington, DC 20003, (202) 544-0900) is usually the first to list new Z-DOS software and is well worth the $20 annual subscription fee. (Single issues are $2.) I generally don't comment on anything I haven't used, and lately I haven't received much Z-DOS stuff. Of course, as soon as I write this, it will flood in. I hope so; the Z-100 is a good machine. . . . **Jerry**

No Problems with Valdocs

Dear Jerry,

As an almost first-time computer user I feel compelled to defend the Epson QX-10 computer and its Valdocs system. You were too harsh in your judgment of it and missed the point of who the system was really designed for. I purchased one of the first systems released and have had next to no difficulties with it.

As a way of introduction, I'm a physician with only a peripheral interest in computers up to now. I am a charter subscriber to BYTE and bought a Radio Shack TRS-80 Model I computer when it first came out. I learned a lot about computers from the Model I and how to program in BASIC, but I could never get the damn thing to save programs on cassette tapes and I didn't want to add the expense of a disk drive to a diabolical machine that drove me crazy.

So I went back to reading computer magazines and waiting. Then I saw an article in BYTE ("An Introduction to the Human Applications and Standard Computer Interface," Parts 1 and 2, October and November 1982, pages 291 and 379, respectively) by Chris Rutkowski about a new computer system that he was working on; it looked too good to be true. I then found out that a computer store in my town would be carrying it, and I became a permanent fixture in that store. Rumors were rampant—it will be out next month, next week, any day now, by Christmas. I was such a persistent customer (pest?) that when the store received the first QX-10 I took it home even without instructions.

I can honestly say that I have never taken a complex piece of machinery out of the box, plugged it in, and had it work as I thought it should with fewer problems. It has changed my life. I have a problem with poor handwriting (typical physician?) and spelling. To use a typewriter involves a high frustration level, much time, and reams of paper. My use of a computer involves letters, short papers, and minutes of meetings. The Ep-

son QX-10 has done this with no problems whatsoever.

My three daughters watched over my shoulders and wanted to use it for school work and letters to their friends. I let them try and, again, no problems. In fact, I had to give them each their own data disk so I could find my own material.

The clincher happened when I tried another word processor. I wanted to try a spreadsheet and a dictionary; I got a deal on a package of four programs from Peachtree Software. As this package included Peachtext, I decided to try it. It includes some features not found on the Valdocs program. I spent most of one weekend on the self-instruction book and got about halfway through it. A week later when I got back to it I had to start at the beginning. I'm sure that I could learn it, but unless I used it every day I would have the same problem each time I went back to it. I just returned from a two-week vacation, and using my QX-10 with the Valdocs program was like finding an old friend.

I haven't had any problems with lost data. I use Control-M to change data disks and periodically press Menu and then Undo to save material as I write it. This takes about 10 seconds of my time. I guess if I got used to a faster program than Valdocs, I might enjoy it, but as it is, I can live with it!

I will say that computers seem to be like a virulent virus. I now am making a pest of myself at the computer store again, waiting for the TPM primer and the Valdocs technical manual. I'm anxious to find out more about what goes on in my computer and how to make it do all sorts of wonderful things. I have bought books on BASIC, assembly-language programming, CP/M, Supercalc, etc. In a year or two, I might agree with your criticism. Who knows? But for now, don't take my QX-10 and Valdocs away from me.

By the way, I agree with you about the Epson FX-80 printer. It is quiet and seems to print well but is not at all easy to load. It does work fine with form-feed paper but not with individual sheets. My haunt of the computer store paid off yesterday, however. I now have a Comrex CR-II printer ($600), and it seems to correct all of the above-mentioned problems.

Herbert Thompson
Decatur, IL

I'm glad you like your machine. Heaven knows, the QX-10 has got to be a lot better than no computer at all, and it certainly is easy enough to get running. (The only one I know of that's easier to get going right out of the box is the Eagle 1600). Moreover, if you intend to print only on continuous paper, without using stationery or letterhead, Valdocs isn't so bad (except that it takes too long to address the envelope).

One question: why was your letter to me done on a Selectric typewriter instead of on your machine? . . . **Jerry**

And the Next Five Years

Dear Jerry,

The next time you unlock your crystal ball to look into the future, you might want to have it checked out first. When you used it to write "The Next Five Years in Microcomputers" (September, page 233), it seems to have been looking into my window rather than the future.

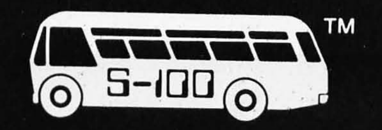
I am using a multiuser, multiprocessor system with a custom-designed serial board that enables me to appear to be five "virtual terminals." I can run up to five separate programs and jump back and forth between them by pressing function keys. The programs continue to run and update their own virtual-terminal screen even if they are not currently being displayed on the "real" terminal. When I jump back to a program, its current screen (including all character attributes) is displayed from memory in the custom-serial board. The board can also be used to allow two terminals to appear as two virtual terminals each. The multiprocessor consists of a main Z80 with 64K, three satellite Z80s with 64K, an 8088 with 256K, and a 68B09E with 128K. All run under Micromation's M/NET, a derivative of Digital Research's MP/M.

Frank Korzeniewski
Berkeley, CA

It sounds like a wonderful system. Not long after I wrote "The Next Five Years. . ." I found out some other outfits, including Compupro, had some pretty neat tricks up their sleeves.

In my defense, two things: "The Next Five Years. . ." was written as a speech to be delivered in early spring, and I only said these things would happen in the next half decade, not what part of it! Some of what I predicted hasn't happened yet. . . . **Jerry**■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE Publications, POB 372, Hancock, NH 03449. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.



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Book Reviews

Legal Care for Your Software

Daniel Remer
Nolo Press
Berkeley, CA: 1982
232 pages, softcover,
$19.95

Reviewed by
Ed Bernstein

Legal Care for Your Software by Daniel Remer is a step-by-step, simply written, and thorough guide for anyone who writes or publishes commercial computer software or who wonders if it would be worth the trouble to do so. The book is full of examples, explanations, and even do-it-yourself legal forms that are basic to anyone trying to untangle the web of software law. Remer's point is that you may be the most talented programmer alive—and may deserve to be the richest—but if you aren't just as smart when it comes to the law, you could be in trouble.

Remer, an attorney who serves as legal counsel to several software companies, never forgets what many programmers learn the hard way: although the law may try to keep pace with technology, the fact is that it is often left "from months to centuries behind." Software can, of course, be legally protected, but the programmer's challenge is figuring out which legal methods apply and how to go about putting them in place.

Because no one law applies to every situation, Remer explains carefully, and with humor, the relative merits of trade secrets, copyright and patent protection, trademarks, contracts, licensing agreements, and so on. Plenty of specific examples serve to illustrate each case.

But his book isn't designed to replace lawyers, Remer says. In many complex cases, or in cases where mistakes have already been made, a lawyer may indeed be needed. But a knowledgeable author or publisher can save time and money by understanding that "If you want full legal protection for your software, you are going to have to do much of the work yourself."

Protecting code is a case in point. The ways to protect source code (the actual language the programmer uses, frequently in a high-level language such as BASIC, FORTRAN, or FORTH) may be far different from those used to protect object code (the low-level instruction to the computer created by the source code).

Trade-secret law applies to both source and object code, Remer explains, and it is the industry's favorite way to protect software. But, as Remer notes, there are weaknesses inherent in trying to protect code—the programmer's ability, for example, to "keep a zipped lip." He also outlines a variety of other procedures that ensure that trade-secret status remains in place, including several nondisclosure agreements.

Copyright protection is among the easiest to obtain; your software is, in fact, "born" with a copyright that makes it illegal for anyone else to copy it. But you have no protection against a fellow programmer who independently produces a program that just happens to operate exactly like yours. A copyright offers protection of an *expression* of an idea, not an idea itself. Two programs can produce identical results, but both can be copyrighted if they accomplish that task in unique ways.

Patent protection sounds like the perfect solution because it protects not only the expression of the idea but the idea itself. Unfortunately, software is almost never patentable, Remer says, and even if it were, the time and legal trouble involved in obtaining a patent could easily exceed the lifespan and value of the program itself.

Trademarks serve only one purpose: protecting the name of a program.

Remer warns, at some length, about protecting yourself as well as your software. He discusses a variety of ways to limit personal liability in the event of unhappy customers, an inevitability in the real world.

Finally, the book provides copies of various contracts, agreements, and disclaimers that you can customize for your own applications. The sample forms and contracts—nearly 100 pages of them—may be the most useful part of the book. A careful reading of these forms can be as educational as the chapters that explain them.

Remer writes clearly and with plenty of common sense. It's hard to imagine a more useful or less intimidating guide to the legal complexities of protecting software. ■

Ed Bernstein (30 Belle Ave., Fairfax, CA 94930) is director of editorial development for Broderbund Software Inc. of San Rafael, California.


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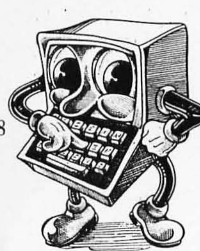
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What's New?

TAXING SOFTWARE

Tax Package Handles More Than 30 Forms

The Micro-Tax tax-preparation system can compute and print more than 30 IRS schedules and forms for multiple clients, partnerships, and corporate returns. Depreciation is computed by individual items or groups of items. Other tax-computation abilities include underpayment penalties, self-employment taxes, minimum and alternative minimum tax, and income averaging. Micro-Tax is said to be easy to use because it calls for simple prompts and organizes data entry in a sequence that's similar to that of manual tax preparation.

Micro-Tax is available for the DEC Rainbow 100 and MS-DOS- and CP/M 8080-, Z80-, 8085-, and 8086-based systems. Three versions are offered: personal, commercial accountant, and partnership and corporate. The home computer Micro-Tax costs $195. The other versions are $1000 each. Annual updates and state tax-preparation programs are available. For more information, contact Microcomputer Taxsystems Inc., Suite A, 6203 Variel Ave., Woodland Hills, CA 91367, (818) 704-7800.

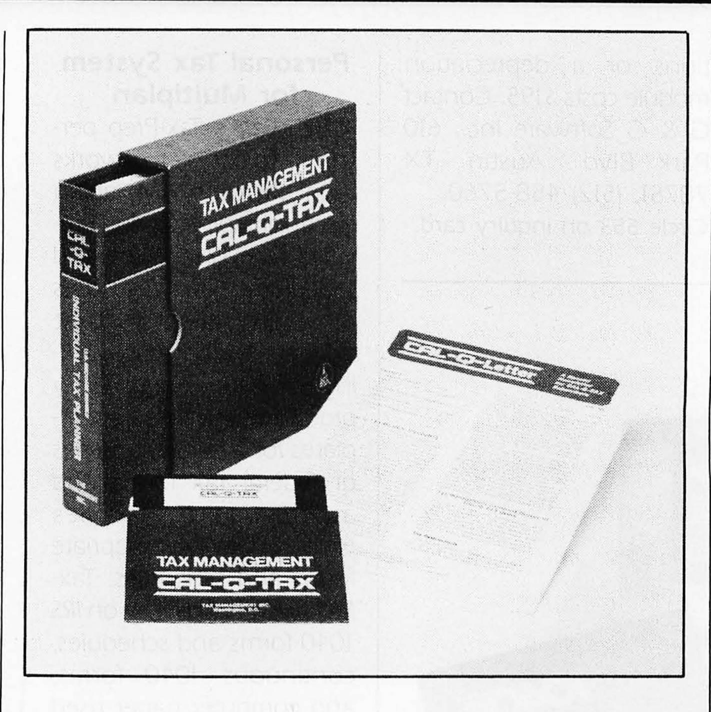
Circle 550 on inquiry card.

Individual Tax Planner

The Individual Tax Planner calculates alternative taxes for individuals and fiduciaries for 1983 and beyond. Projections for multiple years and cases are displayed on screen, and instant recalculations in a worksheet format allow rapid examination of the consequences of alternative tax plans. Computations include income averaging tax, alternative minimum tax, and automatic indexing of post-1984 years. Client information can be saved to disk for printing out comprehensive reports. Full help screens are provided.

The Individual Tax Planner for 1983 is available for a first-year subscription price of $595, which includes documentation and toll-free assistance. An IBM or IBM-compatible computer with 128K bytes of memory, two disk drives, a monitor, and a printer are required. For further information, contact Tax Management Inc., 1231 25th St. NW, Washington, DC 20037, (800) 372-1033; in Maryland, (800) 352-1400; the District of Columbia, 258-9401.

Circle 557 on inquiry card.



Professional and Personal Tax Programs

Aardvark/McGraw-Hill markets tax-preparation programs for professional and personal use. In addition to standard tax calculations, Professional Tax Plan Version 3.0 can compute self-employment taxes under the regular method, taxable unemployment compensation, taxable Social Security benefits for 1984 and after, and limitations for most credits. It can generate an investment report that summarizes the after-tax effect of investment assumptions; additional reports, such as income averaging, are possible. Other features include income inputs, help screens, a file-information screen, and a calculator function. It runs on Apple, Hewlett-Packard, IBM, and CP/M systems. The suggested retail price is $350.

For home use, Aardvark/McGraw-Hill offers the Personal Tax Planner. This $99 program, which runs on Apple and IBM Personal Computers, can handle returns for homeowners and renters and one- or two-income households. Personal Tax Planner will cipher short- and long-term capital gains and losses, the purchase or sale of real estate, and business. It's available at bookstores and computer retailers nationwide. For more information, contact Aardvark/McGraw-Hill, 783 North Water St., Milwaukee, WI 53202, (414) 289-9988.

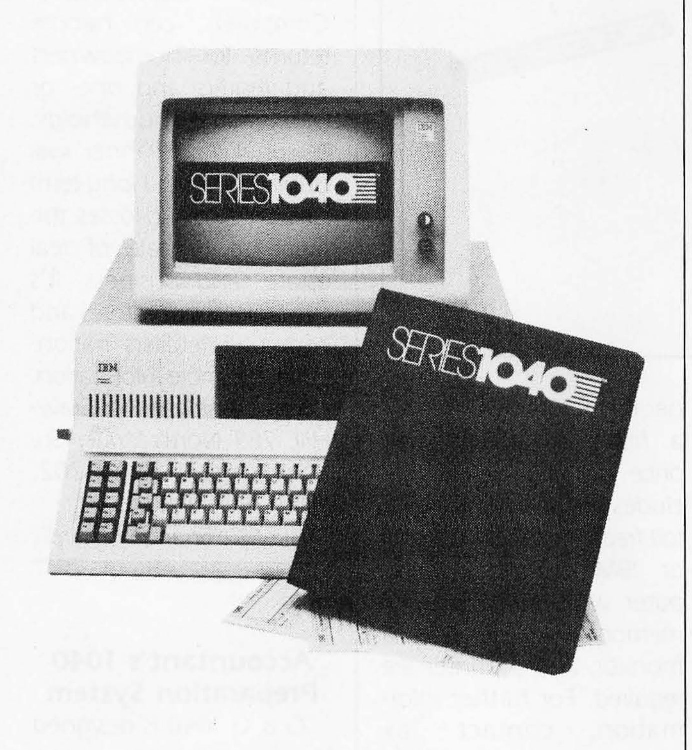
Circle 552 on inquiry card.

Accountant's 1040 Preparation System

G & G 1040 is designed for accountants using CP/M-80 and CP/M-86 computers. This professional-level program features input screens that match IRS forms and the ability to provide choices for the least tax consequences, such as whether Schedule A is preferable to the standard schedule. Additional calculations include optional state sales tax, excess FICA, earned-income credit, income averaging, and minimum tax. The program processes 39 IRS schedules and comes with a batch compute/print mode and a depreciation module. It's claimed that the program calculates an entire return in 10 to 15 seconds.

The suggested list price for the G & G 1040 Professional Series is $750. Annual updates are available. A Starter Series that processes 15 forms but does not include batch operations or a depreciation module costs $195. Contact G & G Software Inc., 610 Park Blvd., Austin, TX 78751, (512) 458-5760.

Circle 553 on inquiry card.



Lettered Schedules, 20 Forms in One Package

The Series 1040 tax-preparation program contains all lettered tax schedules and 20 numbered forms. With Series 1040, you have to enter information only once, which saves time and minimizes errors. All figures and new entries are automatically carried over to applicable forms and schedules. Tax results are calculated and displayed instantly. The display screens replicate 1040 forms. Further highlights are that it asks questions, traps mistakes, and prompts you from item to item. Series 1040 works on such machines as the IBM Personal Computer.

Series 1040 costs $1150. Selected state modules are available. Complete information can be obtained from Calcu-Tax Computer Software Inc., 19-21 West Mount Pleasant Ave., Livingston, NJ 07039, (201) 992-2274.

Circle 556 on inquiry card.

Personal Tax System for Multiplan

EZ Ware's Tax-Prep personal tax system works with Microsoft's Multiplan electronic spreadsheet. Provided with 19 tax forms and schedules, Tax-Prep uses display screens that simulate IRS forms as working templates. A data-entry procedure interrelates templates for a complete series of federal tax forms and automatically applies entered data to appropriate forms and schedules. Tax-Prep will print directly on IRS 1040 forms and schedules, continuous 1040 forms, and computer paper used with an overlay. In addition, it can be used with Multiplan's advanced features to perform tax planning, budgeting, and analysis.

Tax-Prep works with the Apple, Compaq, TI Professional, IBM PC, and Zenith Z-100. Complete with a manual and tutorial, it costs $89.95. Annual updating is available. Tax-Prep is available factory-direct from EZ Ware Inc., 17 Bryn Mawr Ave., Bala Cynwyd, PA 19004, (215) 667-4833.

Circle 551 on inquiry card.

Tax Relief for IBM PC

Tax Relief I and II for the IBM PC have been announced by Micro Vision. Tax Relief II, a professional package, has such features as income averaging, alternate minimum and minimum tax, data and calculation carryover to relevant places, client summaries, and a client directory. Entries can be changed and deleted at any time, and on-line helps aid data entry. Several print options and 25 federal schedules and forms are supported. An IBM PC or PC XT with a minimum of 128K bytes of memory, DOS 2.0, two disk drives, monochrome or color display, and a parallel printer are required. Tax Relief II costs $299. Annual updates are available.

Tax Relief I is designed for individual use. It supports 15 forms and has most of the features of Relief II. The suggested price is $149. For more details, contact Micro Vision, 145 Wicks Rd., Commack, NY 11725, (516) 499-4010.

Circle 554 on inquiry card.

Commodore Tax Program

Northland Accounting's Taxaid was developed by experienced tax accountants for use on Commodore 64 and VIC-20 computers. It computes a line-by-line readout of Form 1040 and related schedules. A manual with step-by-step instructions for data entry is supplied.

Three versions of the program are available: Taxaid I, II, and III. Taxaid I, $19.95 tape or $24.95 floppy disk, is designed for the basic VIC-20. It outputs information to your monitor only. Taxaid II is tailored for 16K-byte VIC-20s. Output is to the monitor or a printer. An expanded version for the Commodore 64, Taxaid III will also output to either the monitor or printer. Taxaid II and III are available on floppy disk or cassette for

$29.95 or $24.95. Contact Northland Accounting Inc., Software Department, 606 Second Ave., Two Harbors, MN 55616, (218) 834-5012.
Circle 555 on inquiry card.

SOFTWARE

Templates Extend 1-2-3

Professional Software Technology has introduced two templates that expand the versatility of Lotus Development Corporation's *1-2-3: Personal Tax Preparer* and *Time and Billing.*

The Personal Tax Preparer condenses 1-2-3 to seven single-letter commands. Save, Print, and Destroy are the only fundamentals you need to prepare Form 1040 and a variety of lettered schedules. Once entered, numbers are automatically carried to the appropriate locations on supporting forms and schedules. Standard features include internal tax tables, screen displays of all forms in use, and the ability to print directly on federal forms.

For its single-letter commands, Time and Billing uses simple associations, such as Z for zapping an account. It accommodates more than 20 people per disk. A total of 10,000 clients can be maintained, each with up to 2000 billing entries. It shows numbers as they are entered, calculations as they are made, and the interrelationships between entries or the bottom line. Any system of keeping time slips can be used. Time and Billing lets you customize up to 30 abbreviated service codes, which minimizes billing-entry descriptions. Receivables are monitored, and the aging of accounts is displayed.

Both programs work with 1-2-3 Release 1A and any computer with 256K bytes of memory and a hard-disk or two floppy-disk drives. Previous knowledge of 1-2-3 is not necessary. Each program retails for $175. For full details, contact Professional Software Technology, POB 269, Rockport, MA 01966, (617) 546-3494.
Circle 567 on inquiry card.

Fast Word Processor

The Qwerty word processor from HFK Software can keep pace with you even if you can type 140 words per minute. Qwerty provides variable margin settings ranging from 1 to 150 columns, tab stops, paragraph indentations, up and down scrolling, forward/backward search and search and replace operations, and block moves. Dynamic insertion and typeover with automatic word and back wrap is supported. Text can be dynamically centered, and such character attributes as underscore, boldface, subscript, superscript, double underscore, and strikethrough can be applied during or after text entry. Left, right, and delete operations can be performed by character, word, or line. On-line helps aid operation.

Qwerty supports a wide range of printers. Print options include a number of pitch and line-spacing settings, variable form and character sizes, automatic pagination with widow line elimination, and automatic user-selectable page numbering. Sixteen color sets are available when you use Qwerty with an RGB color graphics monitor.

This program is designed to run on the IBM PC, PC XT, Chameleon, Compaq, and other computers using PC-DOS. With DOS 2.0, 96K bytes of memory are required. Complete with a tutorial workbook, Qwerty costs $325. For $25, you can try a full-function Qwerty. Qwerty is available factory-direct from HFK Software Inc., Old Danbury Rd., Danbury, NH 03230, (617) 259-0059.
Circle 559 on inquiry card.



Printer-Control Program

Set-FX, a machine-language printer-control program for Epson FX-80/100 printers and the IBM PC or the Compaq portable, has been introduced by Softstyle Inc. With Set-FX, Epson printers can produce the full IBM PC character set, line graphics, foreign language characters, and math and science symbols exactly as they appear on screen. Menus are provided for setting condensed, emphasized, proportional, and italic characters. Set-FX includes a custom font generator. According to the manufacturer, special fonts can be printed at 160 cps.

Set-FX requires one disk drive and a monitor. Memory requirements are 64K bytes when running under PC-DOS 1.1 or 96K bytes with DOS 2.0. It's compatible with any hard disk operated under PC-DOS and with all Epson print modes. Complete with a manual, quick reference card, and a demonstration program, Set-FX costs $59.95, plus $2 handling. Contact Softstyle Inc., Suite 200, 7192 Kalanianaole Highway, Honolulu, HI 96825, (808) 396-6368.
Circle 558 on inquiry card.

Communications Software and Controller Emulator for Lisa

Apple Computer has introduced a pair of datacommunications products, Lisaterminal and the Apple Cluster Controller, that enable Lisa to interact with mainframe systems. Available at authorized Lisa dealers and through Apple's national account executives, Lisaterminal costs $295, and the Cluster Controller ranges from $4500 to $7000.

Lisaterminal provides Lisa with TTY and DEC VT100/52 terminal emulation and the ability to exchange information via a modem with computers supporting asynchronous protocols. It permits access to remote mainframes and information services such as Compuserve and Dow Jones. Also provided are icons, cut and paste integration between application programs, and multiple windows.

A protocol converter, the Cluster Controller works like an IBM 3270-type cluster controller. When used with Lisaterminal, Lisa can communicate with IBM mainframe networks by mimicking IBM 3278 Model 2 terminal functions. It converts SNA/SDLC or BSC protocols to asynchronous protocols and monitors the flow of information in both directions, ensuring accurate transmissions. Both the Lisa and an attached printer communicate through a single Cluster port. The Cluster Controller can be accessed via a modem, making remote communications with a mainframe possible. The Cluster Controller comes with three or seven serial RS-232C ports for mixing and matching Lisas and printers.

Apple has also announced that Ryan-McFarland Corporation's RM/COBOL and RM/FORTRAN language compilers are available for the Lisa. For more information, contact Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014, (800) 538-9696; in California, (408) 996-1010.

Circle 560 on inquiry card.

Music Synthesizer for Commodore 64

Musicalc converts the Commodore 64's Sound Interface chip into a three-voice music synthesizer. Musicalc lets you play along with preprogrammed melodies, create and store melodies for later playback, and compose music in a variety of styles. Standard features include real-time sequencing, slide controls, modulators, and transposers. Musical creations can be played back through television sets, stereo systems, or professional amplifiers by means of standard RCA patch cords.

The suggested retail price is $74.95. For details, contact Waveform Inc., 1912 Bonita Way, Berkeley, CA 94704, (415) 841-9866.

Circle 563 on inquiry card.

Mouse Commands Integrated Software

Jane is an integrated software package consisting of a word processor, spreadsheet, and a file/list manager. A mouse-driven system employing easily understood pictures and symbols rather than programming instructions is at the heart of Jane's user interface. Access to various applications and the entering of data is performed by pointing the mouse to the appropriate symbol on screen. Each application interacts with the others, and you can work with any or all of the applications through up to four on-screen windows. Window dimensions can be expanded or contracted.

Jane runs on most 8- or 16-bit personal computers, such as the Apple, Atari, Commodore 64, and IBM PC, with 64K bytes of RAM. It comes with the mouse, mouse controller card, and users guide. The suggested retail price is $295. Graphics and communications programs will be available. For complete details, contact Arktronics Corp., 113 South Fourth Ave., Ann Arbor, MI 48104, (800) 225-5275; in Michigan, (313) 769-7253.

Circle 561 on inquiry card.

Software Targeted at Business

Superex International Marketing recently released 15 programs targeted at businesses. Applications focus on wholesalers, retailers, importer/exporters, financial analysts, mail-order houses, and pharmacists. An integrated accounting package with accounts receivable/payable, general ledger, and payroll modules is also available.

Most Superex programs are designed for use on floppy- or hard-disk systems, and many are offered in a special network configuration. A few programs, such as the Pharmacist Assistant, require hard disks. Superex programs support Apple, Columbia, Compaq, Corona, DEC Rainbow, Eagle, Franklin, IBM PC, Texas Instruments Professional, and Toshiba computers. BASICA or GW BASIC is necessary. Under MS-DOS, the minimum memory require-

ment is 128K bytes. Versions for Apple and Franklin need 64K bytes of RAM. Prices range from $300 to $2000. For full particulars, contact Superex International Marketing, 151 Ludlow St., POB 248, Yonkers, NY 10705, (800) 862-8800; in New York, (914) 964-5200.

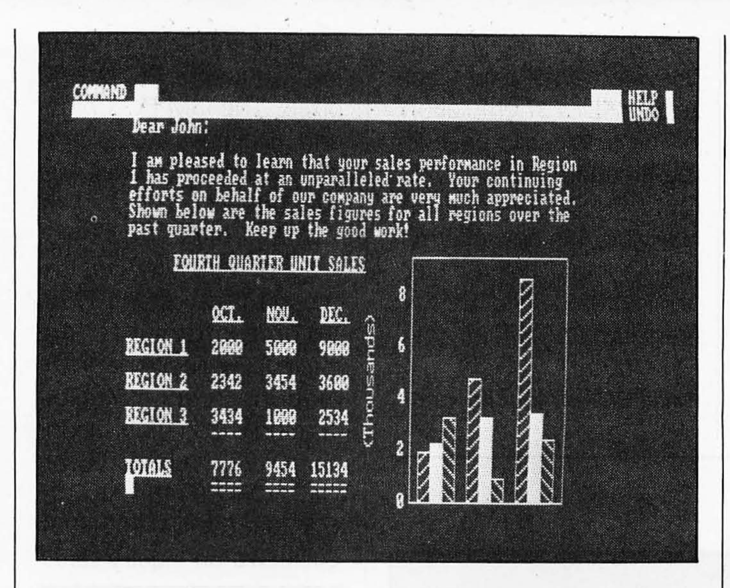
Circle 562 on inquiry card.

Ovation for Integrated Software

Ovation software lets you create, access, move, extract, and manipulate data in various forms without reentering data, preparing different files, or swapping applications modes. This program provides built-in formats for letters, spreadsheets, and notes, customizing capabilities, single-keystroke macro instructions, and advanced macros via text files. Five applications capabilities are provided: spreadsheet, graphics, information management, word processing, and data communications. Different applications can be entered at any time, and data that is entered into a spreadsheet can be turned into a graph or inserted into a report on the same screen. A linking process automatically reflects any changes in associated forms.

Thirty English-language commands, entirely summarized on a single card, are all that you have to learn to run Ovation. The commands are common across applications. Other features include context-sensitive helps, automatic backup and disk numbering, and continuous prompts. Ovation runs on the Tandy 2000 and IBM PC and PC-compatible 8086/8088-based systems using MS-DOS. It requires 256K bytes of memory. A PC XT with a hard disk is recommended, but Ovation will run with two floppy disks. Color and most printers are supported. The suggested retail price is $795. For additional information, contact Ovation Technologies Inc., 770 Dedham St., Canton, MA 02021, (617) 821-1420.

Circle 564 on inquiry card.



Multifunction Package Offers Six Modules

Integrated-6, a multifunction software package for the IBM Personal Computer, is manufactured by Mosaic Software. Its basic ingredients are a relational database, presentation-quality business graphics, a word processor, a spreadsheet, IBM PC-to-PC communications capabilities, and DEC VT100/52 or IBM 3101 terminal emulation. Standard operating features include menu-driven commands, fill-in-the-blank input formats, and built-in help screens. Integrated-6 lets you create, store, analyze, graphically display, combine, and condense information and transfer it between modules and computers. The same information can be output in a variety of formats for presentations.

The database module features disk access with a capacity of up to 100,000 records per file. The graphics module, based on the Superchartman II program, offers nearly 20 graphic styles, ranging from pie and text charts to pie/bar chart combinations. Able to handle as many as 256 columns and 2000 rows, Integrated-6's spreadsheet can use information created and stored in the database for graphic displays or merge it with text to produce reports.

Integrated-6 is written in the C language. It requires a minimum memory of 256K bytes. The company intends to transport it to other computers and enhance its emulation capabilities. The suggested retail price for Integrated-6 is $495. Contact Mosaic Software, 1972 Massachusetts Ave., Cambridge, MA 02140, (617) 491-2434.

Circle 566 on inquiry card.

TERMINALS



Hi-Res Terminal Comes with DIN Keyboard

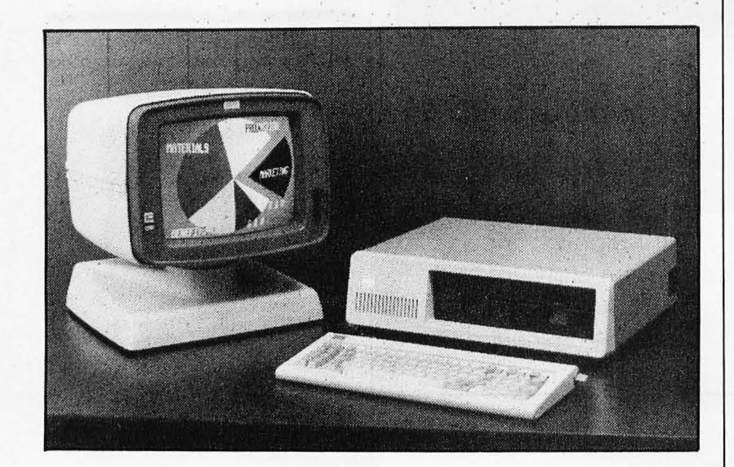
Liberty Electronics' Freedom 200 is a high-resolution, nonglare 12-inch video-display terminal with a 106-key DIN-standard keyboard. This tilt-and-swivel unit features eight foreign character sets, 7 by 9 character cells in a 9 by 12 matrix, a 24-line by 80-character display format, and a user-accessible 25th status line. A software set-up mode and 10 programmable function keys offer operator convenience.

The Freedom 200 has nonvolatile memory for storing function keys and set-up modes during power-down. Nonembedded character attributes for both the visual display and data

entry as well as double-height and double-width characters and 86 graphics characters are provided. Miscellaneous highlights include programmable handshaking protocol, a bidirectional buffered auxiliary port with expandable buffers, programmable answer back, smooth scrolling, adjustable screen time-out, split-screen capabilities with definable scroll regions, and Televideo 950 and Lear-Seigler ADM 31 emulation.

The single-unit price for the Freedom 200 is $745. Quantity discounts are available. For more information, contact Liberty Electronics, 625 Third St., San Francisco, CA 94107, (415) 543-7000.

Circle 569 on inquiry card.



CAD/CAM Graphics Monitor

Colorgraphic Communications Corporation believes that its XL-13 monitor is a cost-effective solution for CAD/CAM graphics requirements. Plug-compatible with the IBM Personal Computer, the XL-13 consists of a bit-mapped graphics board, graphics primitives, a high-performance 13-inch color video display, and a power supply. Its standard screen format is 80 columns by 24 or 48 lines, and character sizes can be 7 by 9 dots in an 8- by 10-dot grid or bit-map programmable. Both text and graphic cursor types are supported, with visible, invisible, blinking, or nonblinking attributes. Graphics features include an escape sequence interpreter for such graphic functions as vectors, arcs, circles, polygons, and parallelograms; draw over and behind; independent draw and erase between graphics and text; geometric and complex fills; 128 fill patterns; zoom, pan, scroll, and scaling; and prefill or post-bounded fill with solid color or pattern.

The graphics board provides a 1024 by 512 by 4 resolution. The 40-MHz bandwidth monitor is swept at 32 kHz horizontally and 60 Hz noninterlace vertically. This combination provides a flicker-free viewing window of 640 by 480 pixels. The IBM PC's high- and medium-resolution and alphanumeric modes are supported.

The XL-13 lists for $3495. A 19-inch monitor version, the XL-19, costs $3995. Volume discounts are offered. For additional information, contact Colorgraphic Communications Corp., 2379 John Glenn Dr., POB 80448, Atlanta, GA 30366, (404) 455-3921.

Circle 570 on inquiry card.



Touch-Sensitive Monitor for IBM

Microtouch Systems has unveiled the Point 1 touch-sensitive monitor for the IBM Personal Computer. Point 1 lets you position the cursor, select from menus, and manipulate graphics with the touch of a finger on the video display. An on-board 8-bit 65F11 microprocessor controls data formats and calibrations and comes with a FORTH interpreter, 2K bytes of RAM for user programs, and 4K bytes of ROM for MTS firmware. Switch settings include 110 to 9600 bps data rates; none, even, odd parity; 1 or 2 stop bits; and software-adjustable parameters. The monitor is available with TTL or composite outputs and amber or green- phosphor screens. Resolution is 1024 by 1024 points at 75 points per second; the data rate is 200 points per second. Output is asynchronous RS-232C. Five commands are used to configure the screen, set parameters, and perform self-tests. Additional pro-



gramming can be done using a proprietary Touch Commands Set and user-defined commands.

Versions of the Point 1 are available for both monochrome and color graphics cards. A 4K-byte EEPROM is available as an option. In small quantities, Point 1 costs less than $850. An OEM kit of the touch screen can be obtained. For complete details, contact Microtouch Systems Inc., Suite 5050, 400 West Cummings Park, Woburn, MA 01801.

Circle 568 on inquiry card.

PERIPHERALS

IBM Data Acquisition and Control

Metrabyte Corporation has announced an A/D data-acquisition and control board for the IBM Personal Computer. The Dascon-1 features 12 bits of digital I/O, 12-bit resolution of analog I/O, four analog input channels with overvoltage protection, switch-selectable input filters, two adjustable voltage references, two 1-mA constant current sources, external interrupt capabilities, and a battery-backed real-time clock. Resolution is 500 microvolts per bit. Optional switch selections can extend the

resolution to 0.5 microvolt per bit on two channels. Two channels contain RTD interfaces for built-in temperature measurements from -200 to 650 degrees Centigrade.

Supplied software includes I/O driver subroutines and such utilities as graphics and calibration/set-up procedures. Options include two channels of 12-bit D/A output with switch-selectable ranges, a screw terminal connector, a solid-state I/O module board, and an electromechanical relay output board. Dascon-1 costs $485, including manual, 37-pin D connector, calibration resistors, and card guide. Options range from $12 to $128.

Also available from Metrabyte is a parallel digital I/O card that provides 24 TTL/DTL-compatible digital I/O lines. It has interrupt input and enable lines as well as external connections to the IBM PC's bus power supplies. The two dozen I/O lines are provided through an 8255-5 programmable peripheral interface. It costs $89. For more information on these products, contact Metrabyte Corp., 254 Tosca Dr., Stoughton, MA 02072, (617) 344-1990.

Circle 571 on inquiry card.



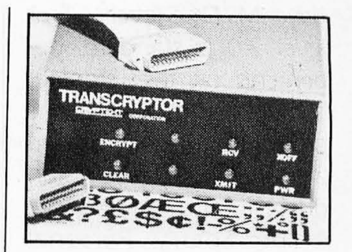
Interface Grapples with Printer

The Grappler CD intelligent printer interface for the Commodore 64 is marketed by Orange Micro. The Grappler's C-1525 printer-emulation mode provides the means for such dot-matrix printers as Epson, Star, Okidata, Prowriter, and NEC to produce graphics and special characters. Standard print features include high-resolution graphics screen dumps, text screen dumps, a transparent operation mode, and block graphics screen dump. Double-size, inverted, rotated, and emphasized graphics are accessible through simple commands. Margin and tab settings, page length, and skip-over perforation are among the Grappler's text-formatting features. More than 22 commands provide printing flexibility.

The Grappler comes with all necessary cables and its own serial ports. Power is drawn from the Commodore's expansion port. The suggested retail price is $139. For the name of your nearest dealer, contact Orange Micro Inc., 1400 Lakeview Ave., Anaheim, CA 92807, (714) 779-2772.

Circle 575 on inquiry card.

Comprehensive Data Encryptor



Transcryptor blocks unauthorized access to computers and terminals, generates its own encryption keys, and automatically encrypts messages upon transmission and decrypts them upon receipt. Transcryptor operates asynchronously, and it automatically adjusts to data rates ranging from 150 to 9600 bps. It has an error-correction feature that causes automatic resynchronization when line-noise errors occur. System hardware includes a Z80 central processor and dual RS-232C ports.

Transcryptor can be easily installed between a computer and modem or a direct line. The suggested retail price is $945. Contact Cryptext Corp., POB 425, Northgate Station, Seattle, WA 98125, (206) 364-8585.

Circle 573 on inquiry card.

SYSTEMS

16-bit Desktop from Sperry

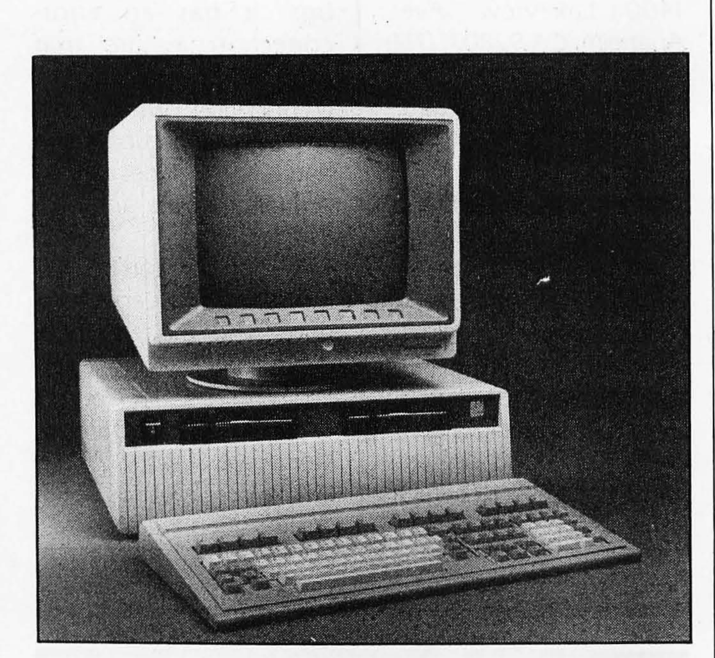
Sperry's 16-bit Personal Computer has built-in communications capabilities. The basic unit contains an 8088 microprocessor, floppy- or hard-disk drives, an asynchronous adapter for mainframe communications, and expansion slots. Standard hardware includes switch-selectable 4.77- or 7.16-MHz clock rates, 128K bytes of RAM, and seven expansion slots.

Two color display monitors are offered for the Sperry Personal Computer: medium and high resolution. The 15-inch medium-resolution display has an 80 or 40 by 25 format, 16K-byte buffer, 320 by 200 or 640 by 200 resolution, and up to 16 colors. Character size is 5 by 7 in an 8- by 8-dot block. The 12-inch color monitor has four resolutions, ranging from 320 by 200 to 640 by 400, a 192K-byte buffer, and the ability to display up to 256 characters. Its character size is 7 by 14 dots in an 8- by 16-dot block. A monochrome display is also available.

Mass storage is provided by 320K- or 360K-byte floppy-disk drives or by a 10-megabyte hard-disk

drive. MS-DOS level 1.25 or level 2.0 is standard, depending on disk storage. Some of the applications programs currently offered are Multiplan, Wordstar, dBase II, and Mail Merge.

The Sperry Personal Computer is available in seven models, differing in regard to monitor and storage selections. A dot-matrix printer is optional. Prices range from $2643 to $5753. For more information, contact Sperry Corp., Computer Systems Division, POB 500, Blue Bell, PA 19424, (215) 542-4213.
Circle 590 on inquiry card.



M68000 Computer Runs Uniplus

Perkin-Elmer's 7350 Professional Computer is a desktop computer founded on the M68000 microprocessor. The 7350 is a modular machine consisting of a display unit, detached keyboard, a 15-megabyte Winchester hard-disk drive, and two double-density double-sided floppy-disk drives. The furnished DOS is Uniplus, a Bell Labs Unix System III derivative. The 7350 is offered in single-user, color graphics, and multifunction cluster console configurations.

The single-user workstation comes with 320K bytes of user memory. The color graphics version has 448K bytes of memory and a palette of 27 colors, 16 of which can be displayed simultaneously. The 1-megabyte multifunction cluster console can accommodate three terminals. Its satellites have complete access to all host programming facilities and most applications. A number of applications packages are available for all versions of the 7350.

The single-user workstation begins at $8400. The cluster console starts at $11,750. For more information, contact Perkin-Elmer, Data Systems Group, 2 Crescent Place, Oceanport, NJ 07757, (201) 870-4768.
Circle 587 on inquiry card.



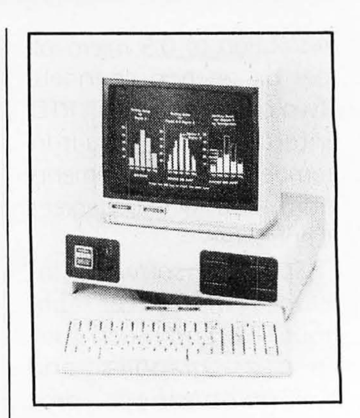
Royal Introduces Personal Computer

Royal Business Machines has introduced the Alphatronic Personal Computer. This Z80A-based machine comes with 64K bytes of RAM and 32K bytes of ROM. It has a BASIC interpreter in ROM and interfaces for a cassette recorder, two disk drives, and a parallel printer. It can be used with a home television or an RGB monitor; the display format is 80 or 40 by 24. Character resolution is formed in an 8- by 12-dot matrix. A 79-character keyboard with six programmable-function keys and separate cursor controls and numeric keypad is provided. For game and tutorial software, the Alphatronic has a built-in cartridge slot.

Slimline 5¼-inch floppy-disk drives and software cartridges are options. The suggested price is $695. For details, contact Royal Business Machines Inc., 500 Day Hill Rd., Windsor, CT 06095, (203) 683-2222.
Circle 586 on inquiry card.

Tandy 2000 Is Powered by 80186

The 16-bit Tandy TRS-80 Model 2000, an MS-DOS-based system, is powered by Intel's 8-MHz 80186 microprocessor. Under MS-DOS, the 2000 can run such software as MS-Windows, Ovation, and Multi-



plan. The 2000 has a 90-key keyboard with 12 function keys and is offered in two configurations, both of which can accommodate up to 768K bytes of RAM. The basic 128K-byte 2000 has twin 5¼-inch floppy-disk drives, totaling 1.4 megabytes of storage. It lists for $2750. The 256K-byte 2000 HD system has a 10-megabyte hard-disk drive augmented with a single floppy-disk drive. It costs $4250.

A 12-inch monochrome and a 14-inch eight-color monitor are offered. The display format is 80 by 25. High-resolution 640 by 400 graphics are optional. Other options include a mouse and a monitor stand.

The Tandy TRS-80 Model 2000 is available at more than 1100 Radio Shack Computer Centers. Contact Tandy Corp./Radio Shack, 1800 One Tandy Center, Fort Worth, TX 76102.
Circle 585 on inquiry card.

MISCELLANEOUS

Tool Identifies Dead Components

Metrifast's Thermoprobe lets you quickly identify dead components without coming into direct contact

with the PCB. A solid-state device consisting of a thermistor probe connected to a modified Wheatstone bridge circuit, Thermoprobe measures minute temperature changes of 1/25 degree Fahrenheit (1/45 degree Centigrade). Because dead ICs, resistors, transformers, and diodes do not emit heat, they can be readily identified on the unit's built-in S-meter, which indicates null to warm as the device is passed above the components.

Thermoprobe is small enough to fit inside a shirt pocket. It's powered by a 9-volt battery. Thermoprobe is available for $21.95, postage paid, from Metrifast, 51 South Denton Ave., New Hyde Park, NY 11040.

Circle 593 on inquiry card.

Money Talks

The American Foundation for the Blind is marketing a device that identifies and vocalizes the value of U.S. paper currency. The machine, known as the PMI (paper money identifier), uses an optical scanning device to identify $1, $2, $5, $10, and $20 bills and a voice synthesizer to announce the value. If a bill is fed into the machine face down, the voice says "over." PMI will also say "please try again" if a bill is tattered or otherwise unrecognizable.

The rectangular PMI measures 3½ by 6 by 15¾ inches and weighs 6 pounds, 2 ounces. Two controls, an on/off switch and a volume selector, are located on the front panel. PMI plugs into any standard three-prong, 120-volt outlet and can be used with a talking cash register developed by the Foundation.

PMI costs $600. Purchasing details are outlined in a free catalog, **Products for People with Vision Problems,** which is available in print or braille from the American Foundation for the Blind, Consumer Products, 15 West 16th St., New York, NY 10011.

Circle 591 on inquiry card.

Rewrite Labels

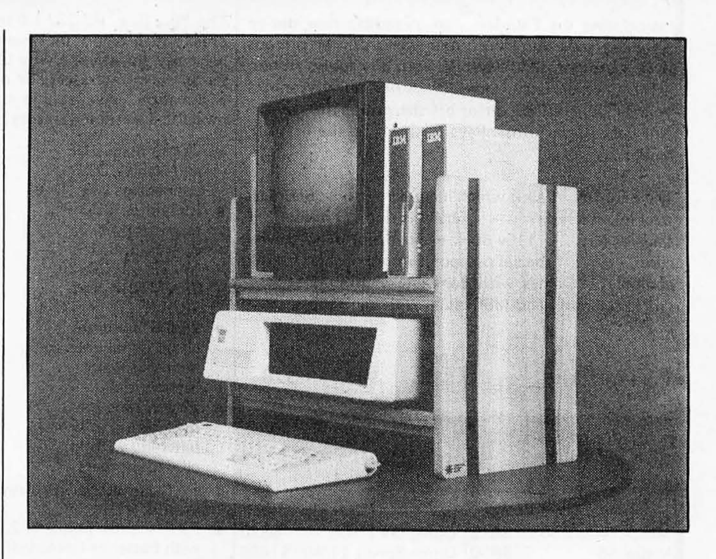
When used with their complementary marking pen, Holman Data Products' Rewrite Labels can be erased with a damp cloth and reused. These 4- by 4½-inch labels have seven lines for information. A package of 100 Rewrite Labels with one marking pen costs $9.95. Quantity discounts are available. Contact Holman Data Products, 2059 West Lincoln, Oroville, CA 95965, (916) 533-5992.

Circle 595 on inquiry card.

Workshelves Adjust to Your Taste

The Stack*Rack line of computer workshelves comprises nine models that can be adapted to any microcomputer on the market. Produced by California Design Works, Stack*Racks feature adjustable shelves that can be set level, sloped, or vertically to suit personal tastes. They are made of solid red oak with an oil finish.

Stack*Racks are available with 14-, 18-, or 22-inch



shelves in single- or double-shelf configurations. Prices range from $38 to $118. For complete details, contact California Design Works, POB 3052, Monterey, CA 93940.

Circle 596 on inquiry card.

Micro Charts Aid Programmers

Micro Logic Corporation's Micro Chart #7 is a double-sided, full-page reference card for 8086 and 8088 programmers. Micro Chart represents the reconstruction of the bits, codes, and special conditions found in data manuals. The data are presented in a fully decoded format, which facilitates programming, debugging, and patching. Areas covered are conversion of instructions to and from hexadecimal, instruction descriptions, cycle time, addressing modes, flag codes, register map, memory map, pinouts, and ASCII codes. Diagrams and cautionary notes are provided as well.

Micro Chart #7 is made of the same type of plastic as a credit card. In lots of one to nine, it costs $5.95, plus $1 postage. Order Micro Chart directly from Micro Logic Corp., 100 2nd St., POB 174, Hackensack, NJ 07602, (201) 342-6518.

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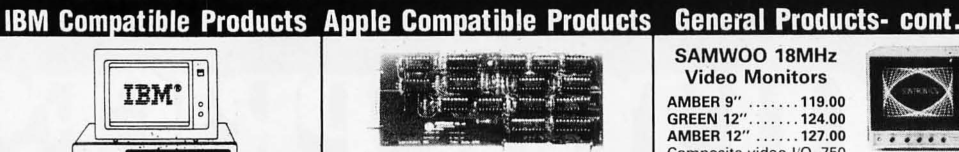
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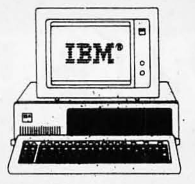


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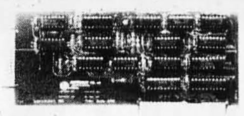
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General Products- cont.

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EPROM & RAM SUPER SALE

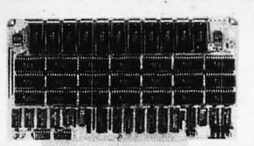
P/N	Description	8-24	25up
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2732	(450nS)	4.40	4.40
2764	(28 pin)	8.95	5.95
4164	(in stock)	Call	Call
6116P-3	(150nS)	6.10	Call

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10MHz, No termination. Includes power indicator and wiring for muffin fan. Uses OK connector for solderless installation and removal of power & reset lines.

S-100 Products



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S-100 Board Uses 6MHz 6116's. ½ Amp max. power, Bank Select plus Extended Addressing allows for multi-memory board set-up. 4 independant 16K Blocks make easy use with multi-user systems. Any 2K RAM may be replaced by a 2716 EPROM.

SBC-880 Z80A CPU, A&T $169.00
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4MHz Z80A CPU boards with Serial/Parallel Ports.

UFDC-1 Floppy Controller, A&T 245.00
UFDC-1 Floppy Controller, Kit 225.00
The UFDC-1 Floppy Controller uses the WD1795 chip which runs either and/or 8"/5¼" Disk Drives.

CLOCK CALENDAR A&T 115.00
CLOCK CALENDAR Kit 95.00
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Special Sale Items

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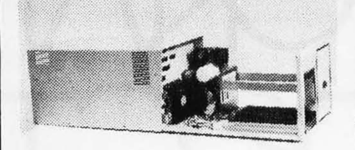
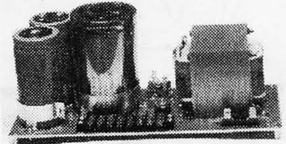
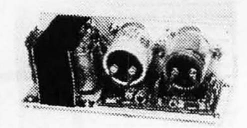
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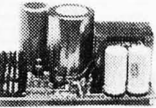
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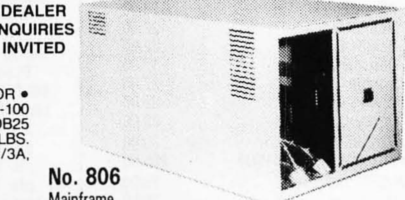
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ASTAR

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Rana Elite III	509.00
Rana Controller	85.00
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PERCOM AT 88 SS/DD Disk Drive w/Printer Port	499.00
RANA Rana 1000—SS/DD Disk Drive	379.00
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WIZARD 80 Col/64K For II E	139.00
WIZARD 80 Col/ For II +	139.00





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Colors Available; color burst asst., beige, black, blue, red, gray

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DDS + 0 2EA SS/DD Siemens FD100-8 Drives w/cabinet 595.00
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Specify—Vertical or Horizontal Cabinet

5¼" SUB ASSEMBLY

DDS + 5 1EA SS/DD Disk Drive (SA400L) 239.00
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Hayes Smart 1200 .... 499.00
Multi-Tech MT 212 AD (1200/300) 475.00
Novation J-Cat 300 .... 119.00
U.S. Robotics 212A Auto Dial 469.00
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USI PI-3 (20 MHZ) Hi-Res/80 Col/12" 129.00

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Amdek I + Composite w/audio 275.00
Princeton HX-12-RGB (For IBM-PC) 469.00
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Slots	Bare Bd	A + T	w/card cage	bare card cage
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6	20.00	48.00	70.00	22.00
8	25.00	69.00	100.00	31.00
12	30.00	99.00	140.00	41.00
18	45.00	150.00	200.00	50.00
22	60.00	185.00	—	75.00

All card cages will accommodate a 4" fan
Add $20.00 for 1 fan-Add $30.00 for 2 fans

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SDS-MUX-RS232 multiplexer bd $235.00
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SDS-Turbodos-Multi-user for master & slaves $645.00

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All mainframes except IMF + DD6F have EMI filter, 2 AC outlets, 15 ea. DB25, 2 ea. 50 pin, 2 ea. 34 pin, 1 ea. Centronic cutouts, power supply for 8" MF (−5V1A/ + 5V6A/ + 8V16A/ ± 16V3A/ + 24V6A)

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S-100•Time in hrs, min, sec.•AM/PM or Military Format•Date in Mo., Day, Yr, Day of Week & Leap Year recognition•4 hard interrupts (1024 Hz, 1 Hz, 1 min, 1 hr) • On board battery (will last 14 mos. w/no power on)

QTC-CCS-BB (S-100) $45.00
QTC-CCS-A (A + T) for S-100 .... $100.00

S-100 PRODUCTS

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PN-2048 Best Bare Board Set Available

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QTC-EXP + III 256K (CT256) Memory bd./Expandable to 1MG
QTC-FDC 5/8 Floppy disk controller
Bare Board Set $150.00

1) Includes manuals & assembly instructions
2) Parts available
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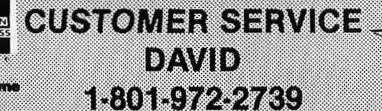
★ CPU/MEM/I/O

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QTC-SBC 2/4 A A + T (SBC880) $265.00
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QTC-EXP + III 64K A + T (CT256) $375.00
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QTC-I/O + A + T $300.00
QTC-ADA ADA Converter A + T $400.00
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CPU 8086/8087 .... CALL
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Ram 17-64K .... CALL
Ram 21-128K .... CALL
Interfacer 1 .... CALL
Interfacer 2 .... CALL
Interfacer 3 .... CALL
Interfacer 4 .... CALL
System Support I .... CALL
Active Terminator .... CALL
Enclosure 2 (Desk) .... CALL
Enclosure 2 (Rack MT) .... CALL
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M-Drive H .... CALL
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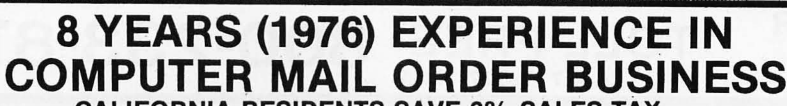
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Daisywriter Tractor 140.00

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NEC3550 35CPS IBM 1,850.00
NEC7710 55CPS Serial Daisywheel 1,995.00
NEC7715 55CPS Diablo Comp Daisywheel 1,995.00
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Microline 93 (PAR-160CPS-LTR-15") .... CALL
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Microline 84S (SER-200CPS-LTR-15") .... CALL

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Gemini 15X (PAR-120CPS-15") .... CALL
Gemini Delta 10 (Par-160CPS-10" 8K buffer serial) .. CALL

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Commodore 64 Intf. Bd. **72.00**

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FRANKLIN 1000 w/color **799.00**
FRANKLIN 1200 Starter includes CPU 1 F.D. 80 col **1,625.00**
FRANKLIN 1200 OMS includes CPU-2 F.D. and bundled software **1,825.00**

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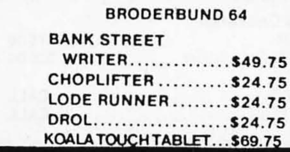
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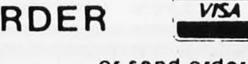
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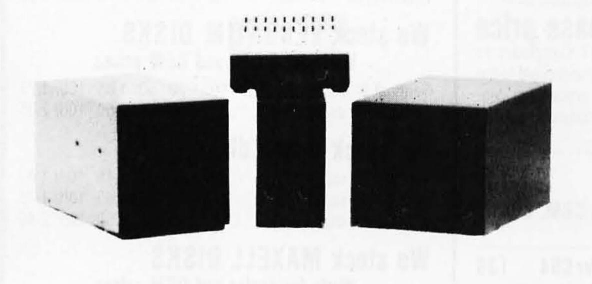
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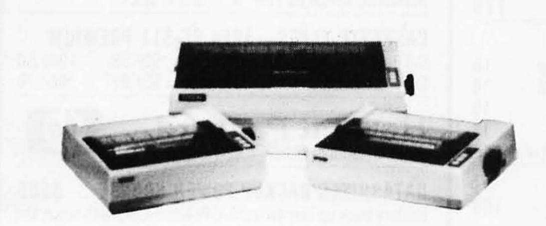
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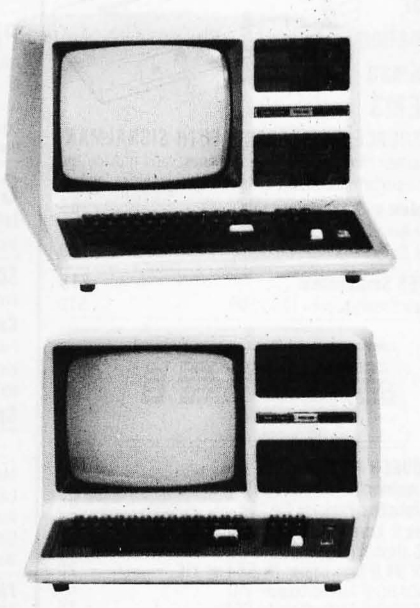
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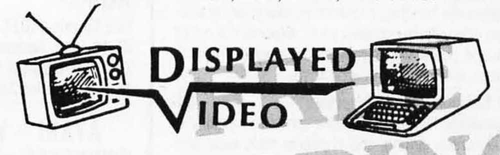
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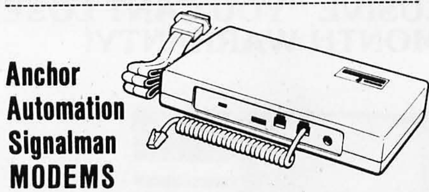
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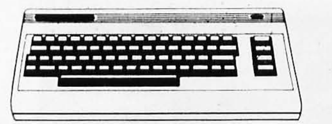
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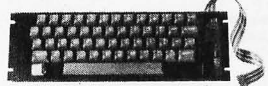
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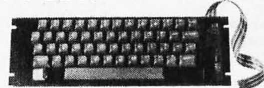
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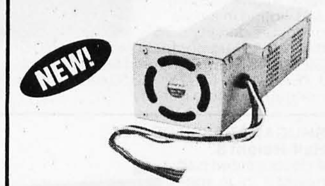
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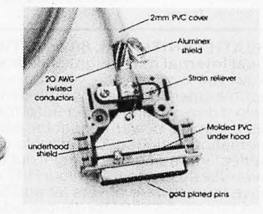
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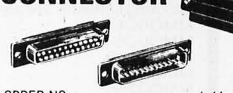
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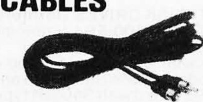
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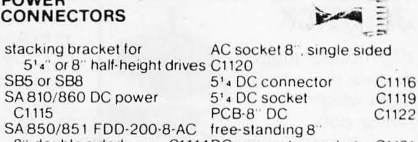
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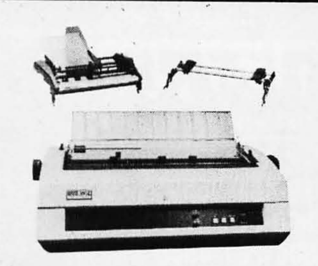
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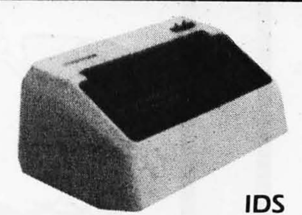
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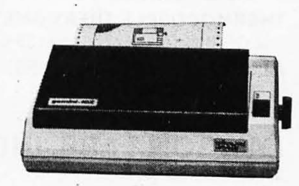
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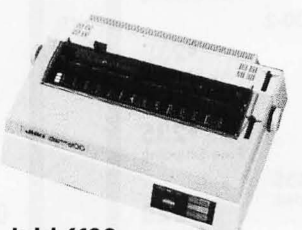
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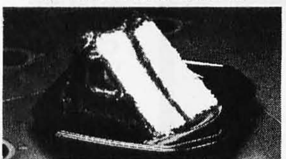
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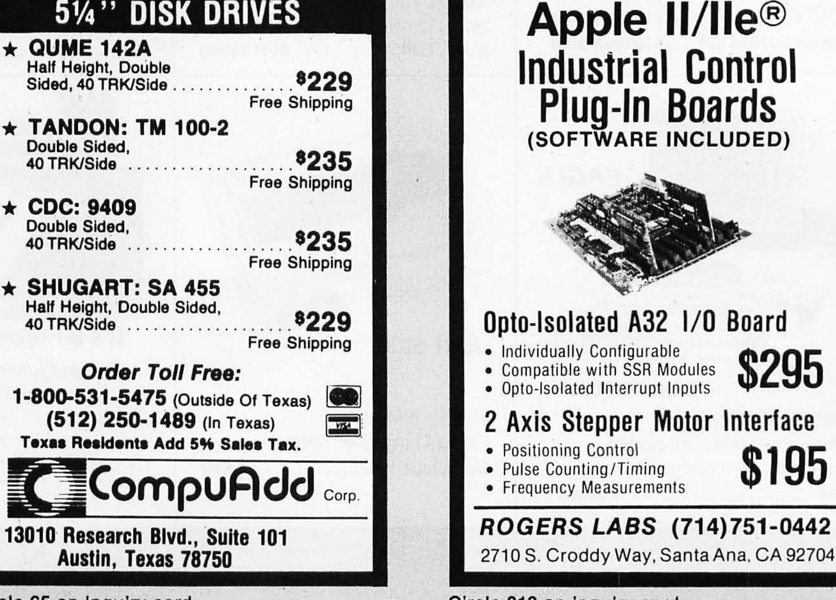
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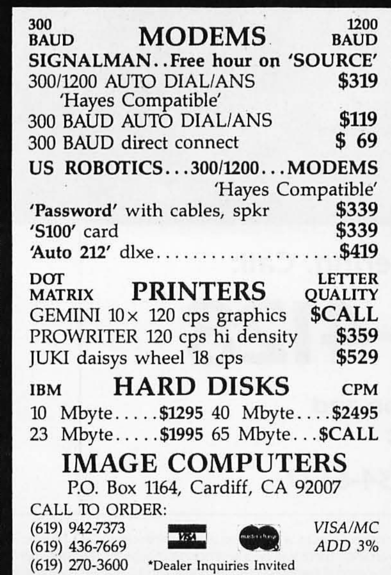
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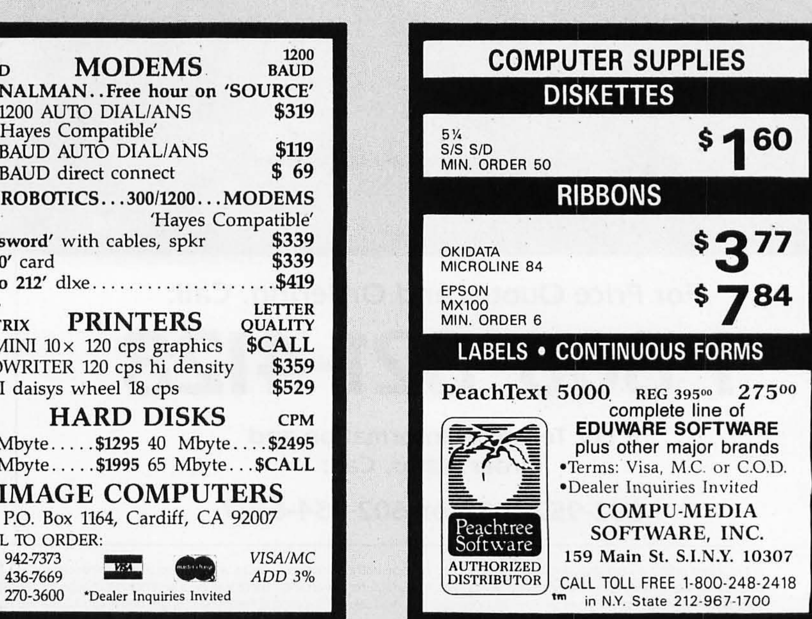
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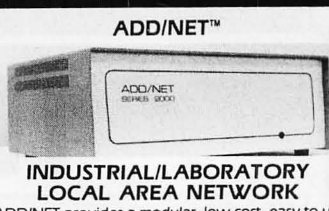
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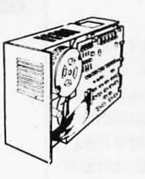


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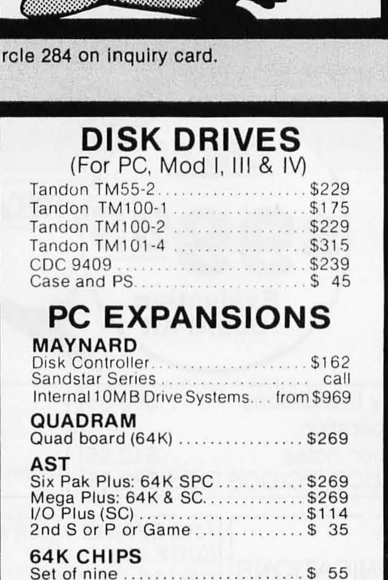


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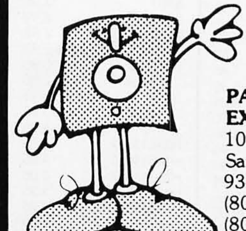


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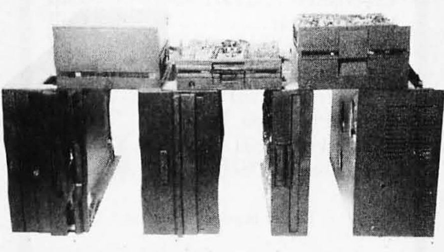
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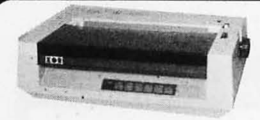
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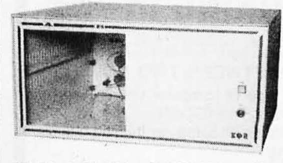
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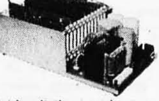
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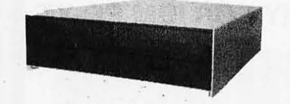
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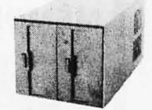


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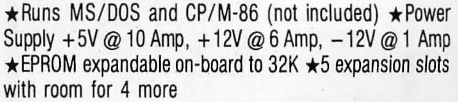
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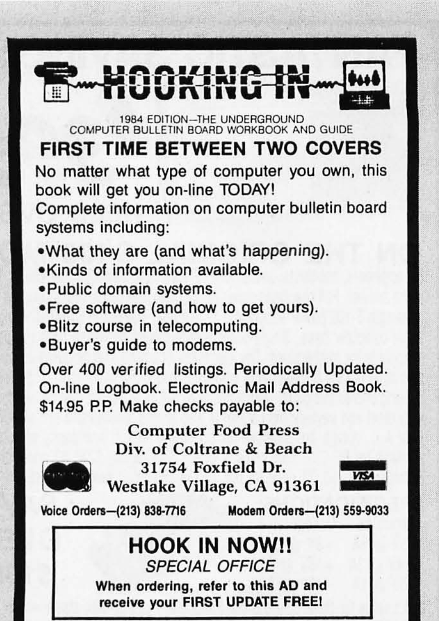
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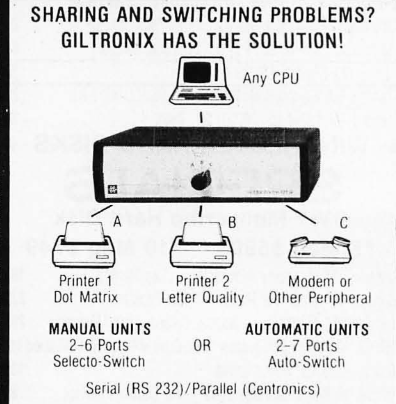


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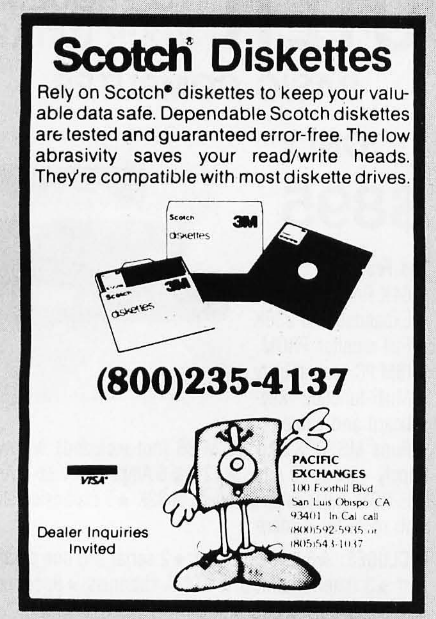
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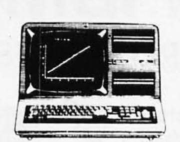
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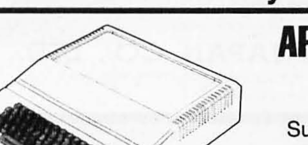


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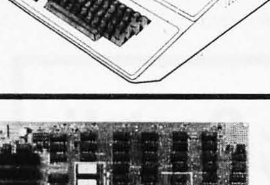
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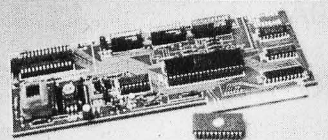
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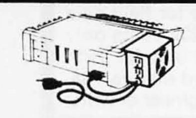
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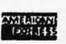
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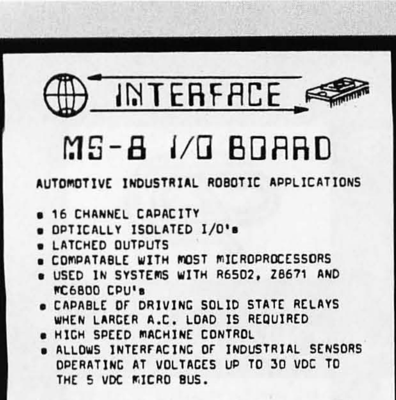
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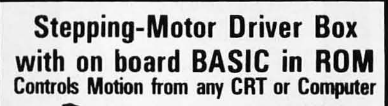
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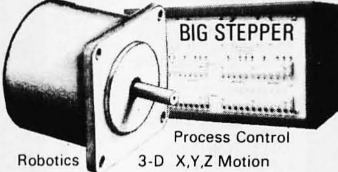
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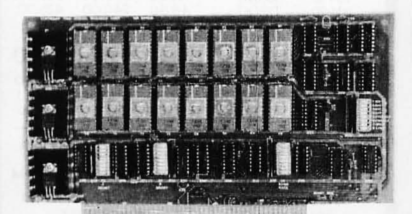
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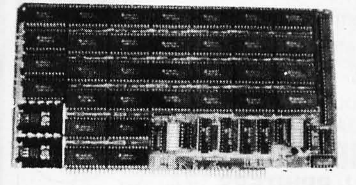
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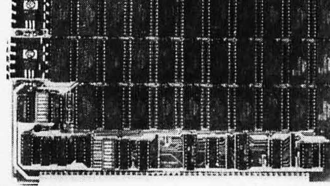
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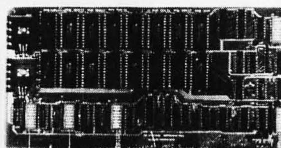
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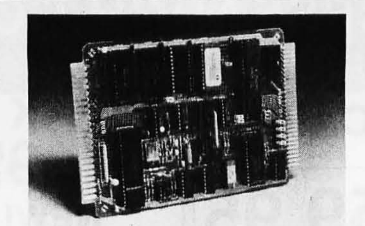
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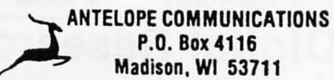
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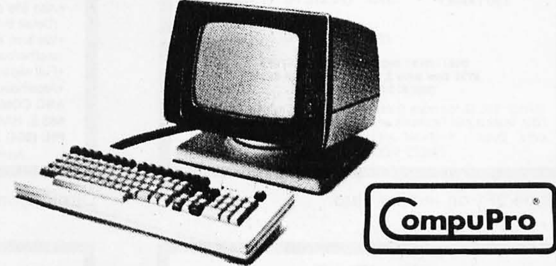
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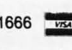
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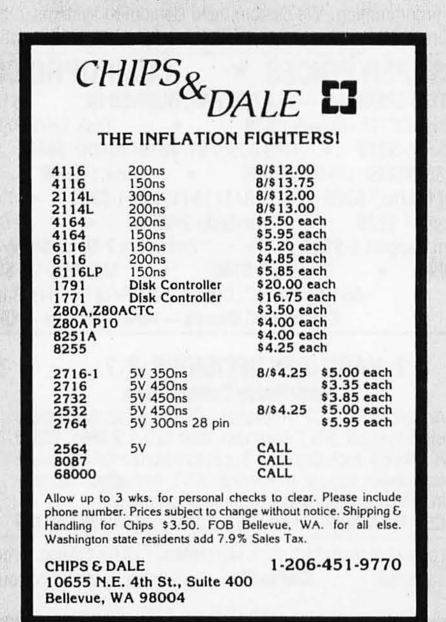
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32K *List Price 260.00*	**$199.95**

Parallel/Serial

8K *List Price 199.00*	**$169.95**
32K *List Price 260.00*	**$199.95**

Serial/Serial

8K *List Price 199.00*	**$169.95**
32K *List Price 260.00*	**$199.95**

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Practical Peripherals, Inc

Stand-alone Microbuffers

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Serial, 32K *List Price 299.00*	**$229.95**
Serial, 64K *List Price 349.00*	**$269.95**
64K add-on board *List Price 179.00*	**$149.00**

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Parallel, 32K *List Price 299.95*	**$229.95**
Serial, 16K *List Price 259.95*	**$189.95**
Serial, 32K *List Price 299.95*	**$229.95**

Microbuffers for Epson Printers

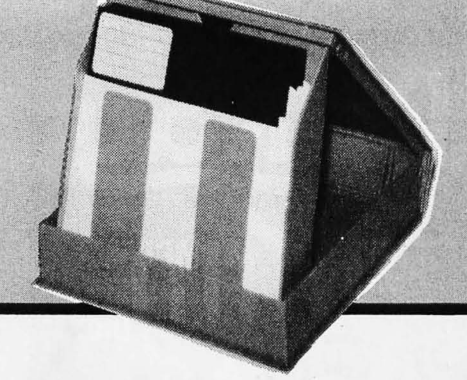
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12 Slot kit *List Price 110.00* **$69.95**
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2102L-2	1024 x 1 (250ns) (LP)	1.45
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2114	1024 x 4 (450ns)	8/9.90
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TMS4044-4	4096 x 1 (450ns)	3.45
TMS4044-3	4096 x 1 (300ns)	3.95
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HM6116-2	2048 x 8 (120ns) (cmos)	8.90
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LP = Low Power   Qstat = Quasi-Static

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4164-200	65536 x 1(200ns) (5v)	CALL
4164-150	65536 x 1(150ns) (5v)	CALL

5V = single 5 volt supply

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2708	1024 x 8 (450ns)	3.90
2758	1024 x 8 (450ns) (5v)	5.90
2716	2048 x 8 (450ns) (5v)	3.90
2716-1	2048 x 8 (350ns) (5v)	5.90
TMS2516	2048 x 8 (450ns) (5v)	5.45
TMS2716	2048 x 8 (450ns)	7.90
TMS2532	4096 x 8 (450ns) (5v)	5.90
2732	4096 x 8 (450ns) (5v)	4.90
2732-250	4096 x 8 (250ns) (5v)	8.90
2732-200	4096 x 8 (200ns) (5v)	10.95
2764	8192 x 8 (450ns) (5v)	9.90
2764-250	8192 x 8 (250ns) (5v)	13.95
2764-200	8192 x 8 (200ns) (5v)	23.95
TMS2564	8192 x 8 (450ns) (5v)	16.95
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27128	16384 x 8Call	Call

5v = Single 5 Volt Supply

74LS00

74LS00	.23	74LS92	.54
74LS01	.24	74LS93	.54
74LS02	.24	74LS95	.74
74LS03	.24	74LS96	.88
74LS04	.23	74LS107	.38
74LS05	.24	74LS109	.38
74LS08	.27	74LS112	.38
74LS09	.28	74LS113	.38
74LS10	.24	74LS114	.38
74LS11	.34	74LS122	.44
74LS12	.34	74LS123	.78
74LS13	.44	74LS124	2.85
74LS14	.58	74LS125	.48
74LS15	.34	74LS126	.48
74LS20	.24	74LS132	.58
74LS21	.28	74LS133	.58
74LS22	.24	74LS136	.38
74LS26	.28	74LS137	.98
74LS27	.28	74LS138	.54
74LS28	.34	74LS139	.54
74LS30	.24	74LS145	1.15
74LS32	.28	74LS147	2.45
74LS33	.54	74LS148	1.30
74LS37	.34	74LS151	.54
74LS38	.34	74LS153	.54
74LS40	.24	74LS154	1.85
74LS42	.48	74LS155	.68
74LS47	.74	74LS156	.68
74LS48	.74	74LS157	.64
74LS49	.74	74LS158	.58
74LS51	.24	74LS160	.68
74LS54	.28	74LS161	.64
74LS55	.28	74LS162	.68
74LS63	1.20	74LS163	.64
74LS73	.38	74LS164	.68
74LS74	.34	74LS165	.94
74LS75	.38	74LS166	1.90
74LS76	.38	74LS168	1.70
74LS78	.48	74LS169	1.70
74LS83	.59	74LS170	1.45
74LS85	.68	74LS173	.68
74LS86	.38	74LS174	.54
74LS90	.54	74LS175	.54
74LS91	.88	74LS181	2.10

74LS189	8.90	74LS363	1.30
74LS190	.88	74LS364	1.90
74LS191	.88	74LS365	.48
74LS192	.78	74LS366	.48
74LS193	.78	74LS367	.44
74LS194	.68	74LS368	.44
74LS195	.68	74LS373	1.35
74LS196	.78	74LS374	1.35
74LS197	.78	74LS377	1.35
74LS221	.88	74LS378	1.13
74LS240	.94	74LS379	1.30
74LS241	.98	74LS385	1.85
74LS242	.98	74LS386	.44
74LS243	.98	74LS390	1.15
74LS244	1.25	74LS393	1.15
74LS245	1.45	74LS395	1.15
74LS247	.74	74LS399	1.45
74LS248	.98	74LS424	2.90
74LS249	.98	74LS447	.36
74LS251	.58	74LS490	1.90
74LS253	.58	74LS624	3.95
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74LS259	2.70	74LS668	1.65
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74LS273	1.45	74LS674	9.60
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74LS279	.48	74LS683	3.15
74LS280	1.95	74LS684	3.15
74LS283	.68	74LS685	3.15
74LS290	.88	74LS688	2.35
74LS293	.88	74LS689	3.15
74LS295	.98	74LS783	23.95
74LS298	.88	81LS95	1.45
74LS299	1.70	81LS96	1.45
74LS323	3.45	81LS97	1.45
74LS324	1.70	81LS98	1.45
74LS352	1.25	25LS2521	2.75
74LS353	1.25	25LS2569	4.20

6500

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6502	4.90
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6505	8.90
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6522	7.90
6532	9.90
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6551	10.85

2 MHZ

6502A	6.90
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6551A	10.95

3 MHZ

6502B	13.95

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8216	1.70
8224	2.20
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8228	3.45
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8237-5	20.95
8238	4.45
8243	4.40
8250	9.95
8251	4.45
8253	6.90
8253-5	7.90
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8255-5	18.95
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8257-5	8.90
8259	6.85
8259-5	7.45
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8279	8.90
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8284	14.95
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8287	6.45
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Z80-SIO/2	15.95
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Z80A-CTC	4.90
Z80A-DART	10.95
Z80A-DMA	15.95
Z80A-PIO	4.90
Z80A-SIO/0	15.95
Z80A-SIO/1	15.95
Z80A-SIO/2	15.95
Z80A-SIO/9	15.95

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Z80B-CPU	12.95
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8T96	.88
8T97	.88
8T98	.88
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DP8304	2.24
DS8835	1.94
DS8836	.98

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7805T	.74	7905T	.84
78MO5C	.34	7908T	.84
7808T	.74	7912T	.84
7812T	.74	7915T	.84
7815T	.74	7924T	.84
7824T	.74		
7805K	1.34	7905K	1.44
7812K	1.34	7912K	1.44
7815K	1.34	7915K	1.44
7824K	1.34	7924K	1.44
78L05	.68	79L05	.78
78L12	.68	79L12	.78
78L15	.68	79L15	.78
		LM323K	4.90
78H05K	9.90	UA78S40	1.90
78H12K	9.90		

C,T = TO-220 K = TO-3 L = TO-92

DIP SWITCHES

4 POSITION	.84
5 POSITION	.89
6 POSITION	.89
7 POSITION	.94
8 POSITION	.94

IC SOCKETS

	1-99	100
8 pin ST	.12	.10
14 pin ST	.14	.11
16 pin ST	.16	.12
18 pin ST	.19	.17
20 pin ST	.28	.26
22 pin ST	.29	.26
24 pin ST	.29	.26
28 pin ST	.39	.31
40 pin ST	.48	.38
64 pin ST	4.20	call

ST = SOLDERTAIL

8 pin WW	.58	.48
14 pin WW	.68	.51
16 pin WW	.68	.57
18 pin WW	.98	.89
20 pin WW	1.04	.97
22 pin WW	1.34	1.23
24 pin WW	1.44	1.30
28 pin WW	1.64	1.44
40 pin WW	1.94	1.75

WW = WIREWRAP

16 pin ZIF	6.70	call
24 pin ZIF	9.90	call
28 pin ZIF	9.95	call

ZIF = TEXTOOL (Zero Insertion Force)

CRYSTALS

32.768khz	1.90
1.0 mhz	4.90
1.8432	4.90
2.0	3.90
2.097152	3.90
2.4576	3.90
3.2768	3.90
3.579535	3.90
4.0	3.90
5.0	3.90
5.0688	3.90
5.185	3.90
5.7143	3.90
6.0	3.90
6.144	3.90
6.5536	3.90
8.0	3.90
10.0	3.90
10.738635	3.90
14.31818	3.90
15.0	3.90
16.0	3.90
17.430	3.90
18.0	3.90
18.432	3.90
20.0	3.90
22.1184	3.90
32.0	3.90

RESISTORS

¼ WATT 5• CARBON FILM ALL STANDARD VALUES FROM 1 OHM TO 10 MEG OHM

50 PCS.	1.25
100 PCS.	2.00
1000 PCS.	15.00

BULK DISKETTES

5¼" DISKETTES ATHANA OR NASHUA

SSSD	18.95
SSDD	22.95
DSDD	27.95

5¼" DISKETTES NO LABEL

SINGLE SIDED DOUBLE DENSITY (WITH JACKETS AND HUB RING)

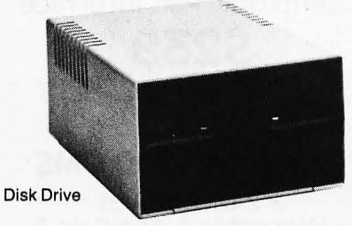
Pack of Ten	$ 16.95
Pack of 100	$149.00

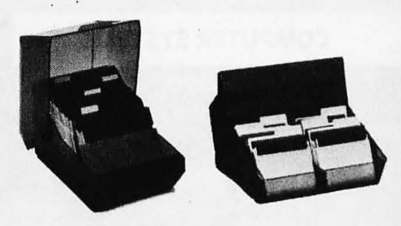
APPLE ACCESSORIES

80 Column Card	129.95
16 K Card	42.50
Fan	38.95
Power Supply	84.95
RF Mod	24.95
Joy Stick (Apple II)	29.95
Paddles Apple	9.95
Z80 Card	129.95
SCRG Switch-A-Slot	19.95
Paddle Adapple	24.95
Extend-A Slot	195.95
Disk Drive	224.95
Controller Card	69.95



Joy Stick


Cooling Fan


Disk Drive



The Flip Sort Plus™

The Flip Sort Plus™ adds new dimensions to storage. Designed with similar elegant lines as the original Flip Sort™, in a transparent smoked acrylic. The Flip Sort Plus™ has a storage capacity of over 100 diskettes and has all the outstanding features you have come to expect from the flip sort Family. **24.95 each**

DoKay

2100 De La Cruz Blvd.
Santa Clara, CA 95050

California Digital

Post Office Box 3097 B • Torrance, California 90503

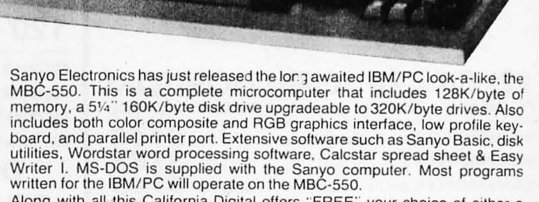
$35 WESTERN UNION EasyLink

California Digital has recently contracted with the Western Union Telegraph Company for the privledge of offering subscriptions to Western Union's new EasyLink data communications network.
Subscribers are able to transmit and receive domestic and international communications from a network of over 1.5 millon Worldwide Telex subscribers. EasyLink also allows access to other Western Union services that till recently have been available only to dedicated Telex installations.
Send telegrams, Mailagrams and computer letters as easy as telephoning Western Union's toll free access line. Your personal computer and modem become your link to the World.
One time $35.00 Installation fee includes EasyLink self teaching user manual, Telex directory and your EasyLink access password.

FREE

Your Choice
Second Drive or Monitor

SANYO
IBM COMPATIBLE
$995



Sanyo Electronics has just released the long awaited IBM/PC look-a-like, the MBC-550. This is a complete microcomputer that includes 128K/byte of memory, a 5¼" 160K/byte disk drive upgradeable to 320K/byte drives. Also includes both color composite and RGB graphics interface, low profile keyboard, and parallel printer port. Extensive software such as Sanyo Basic, disk utilities, Wordstar word processing software, Calcstar spread sheet & Easy Writer I. MS-DOS is supplied with the Sanyo computer. Most programs written for the IBM/PC will operate on the MBC-550.
Along with all this California Digital offers "FREE" your choice of either a second disk drive, or a high resolution green or amber screen monitor. All at the super low price of only $995.
We are currently experiencing an initial shortage of this computer. Please place your orders early. The MBC-550 will be shipped on a first ordered basis.

PRINTERS



$289 Star Gemini

MATRIX PRINTERS

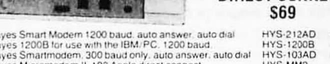
Star Gemini-10X 120 char/sec	STR-G10X	289.00
Star Gemini-15X 100 char/sec 15" paper	STR-G15X	419.00
Star Gemini Delta 10, 160 Char/sec	STR-D10	
Star Coex 80FT friction & tractor	VST-C80FT	229.00
Toshiba P1350, 192 char/sec letter quality	TOS-1350	1495.00
Okidata 82A serial & parallel 9½" paper	OKI-82A	379.00
Okidata 92A parallel interface, 160 char/sec	OKI-92A	479.00
Okidata 83A & parallel 15" paper	OKI-83A	619.00
Okidata 84A & parallel 15" paper	OKI-84A	1019.00
Okidata 2350 (new) 350 char/sec	OKI-2350	1995.00
Epson FX80, 10" 160 char/sec with graphtrax	EPS-FX80	529.00
Epson MX100 with graphtrax 15" paper	EPS-MX100	589.00
NEC8023A parallel 9½" paper, graphics	NEC-8023A	389.00
Anadex 9501A high speed with graphics	ADX-9501A	1099.00
Anadex 9620A 200 char/sec par'l & serial	ADX-9620A	1199.00
Quantex 7030 corespondence quality 180 char/sec	QTX-7030	1595.00
Gorilla low cost dot matrix printer	PRO-7500	189.00
Prowriter 8510 parallel 9½" paper	PRO-8510P	
Prowriter II, parallel 15" paper, graphics	PRO-2P	689.00
Dataproducts B-600-3, band printer 600 LPM	DPS-B600	6985.00
Printronix P300 high speed printer 300 lines per minute	PTX-P300	4250.00
Printronix P600 ultra high speed 600 lines per minute	PTX-P600	5795.00
Transtar 130P par'l, IBM/PC compatible	TNS-130P	629.00

WORD PROCESSING PRINTERS

NEC7710 55 char/second, serial interface	NEC-7710	1979.00
NEC7730 55 char/sec, par'l interface	NEC-7730	1979.00
NEC3550 popular printer designed for the IBM/PC	NEC-3550	1799.00
NEC2050 designed for IBM/PC 20 char/sec par'l	NEC-2050	995.00
Silver Reed EXP500, 14 char/sec, par'l interface	SRD-EXP500	459.00
Silver Reed EXP550 17 Char/sec par'l interface	SRD-EXP550	659.00
Diablo 630 40 char/sec serial	DBL-630	1765.00
Diablo 620, proportional spacing, horz & vert tab 20 cps	DBL-620	879.00
Juki 6100, 18 char/sec, graphic mode	JUK-6100	539.00
Brother HR1A daisy wheel, parallel interface	BTH-HR1P	695.00
Brother HR1A serial interface	BTH-HR1S	779.00
Starwriter F10 serial, 40 char/sec	PRO-F10S	1125.00
Starwriter F10 parallel, 40 char/sec	PRO-F10P	1125.00
Comrex CR1 word processing printer serial intr	CRX-CR1S	729.00
Comrex CR2, 5k buffer, proportional spacing, par'l	CRX-CR2P	495.00

MONITORS

BMC 12A green phosphor 15 MHz composit video	BMC-12A	79.00
BMC 12" high resolution, 20MHz	BMC-12EN	134.00
Zenith ZVM122 Amber Phosphor 12" 40/80 column switch	ZTH-122	119.00
Zenith ZVM123 green phosphor 12" 40/80 column switch	ZTH-Z123	105.00
NEC JB1201 green phosphor 18 MHz composit video	NEC-JB1201	169.00
NEC JB1260 commercial grade composit	NEC-JB1260	129.00
USI Amber screen 12" composit monitor	USI-12A	169.00
Motorola 23" open frame blk/white composit video	MOT-BW23	159.00
Motorola 12" open frame requires horz sync. and power	MOT-BW12	69.00
Conrac 9" open frame requires horz sync & 12v supply	CON-BW9	59.00
COLOR		
BMC AU9191U Color composit video with sound	BMC-9191	249.00
BMC 9191M RGB designed for use with the IBM computer	BMC-9191M	499.00
NEC JC1203DM RGB color monitor	NEC-1203	699.00
NEC JC1201 color composit	NEC-JC1201	339.00
Zenith ZVM134 RGB color suitable for IBM PC	ZTH-Z134	379.00
Comrex color composit with sound	COM-6500	329.00
Amdek Color 1, composit video	AMK-100	329.00



MODEMS

DIRECT CONNECT
$69

Hayes Smart Modem 1200 baud, auto answer, auto dial	HYS-212AD	474.95
Hayes 1200B for use with the IBM/PC, 1200 baud	HYS-1200B	449.00
Hayes Smartmodem, 300 baud only, auto answer, auto dial	HYS-103AD	229.00
Hayes Micromodem II, 103 Apple direct connect	HYS-MM2	279.00
Hayes Micromodem 100, S-100 auto answer, auto dial	HYS-100	319.00
Hayes Chronograph, time & date	HYS-CHR232	199.00
U.S. Robotics 212A 300/1200 baud, auto dial/answer	USR-212A	439.00
Penril 300/1200 auto dial autolog	PEN-12AD	695.00
Universal Data 103LP line power, answer & originate	UDS-103LP	169.00
Universal Data 103LPJ, Auto answer	UDS-103LPJ	219.00
Universal Data 202, 1200 baud, half duplex only	UDS-202LP	219.00
Universal Data 212LP full 1200 baud duplex, line power	UDS-212LP	359.00
Novation J Cat, direct connect, auto answer	NOV-JCAT	115.00
Novation Cat, acoustic connect	NOV-CAT	159.00
Novation SmartCat 103, auto answer, auto dial	NOV-SC103	219.00
Novation SmartCat 103/212, 1200 baud auto dial	NOV-SC212	529.00
Signalman Mark 1, direct connect with terminal cable	SGL-MK1	69.00

TERMINALS

The Wyse 100 features die cast aluminum case, 102 key keyboard and non-glare 26 line green phosphor video display. Split screen both horizontal an vertical makes the WY-100 unusally user friendly. This unique terminal is perfect to enhance any business system.



$795

Freedom 50, split screen, detatchable keyboard	LIB-F50	475.00
Visual 50, detatchable, keyboard selectable settings	VSL-50	619.00
Visual 50 Green screen	VSL-50G	650.00
Visual 330, emulator, 14 inch green phosphor	VSL-33014G	925.00
Ampex Dialogue 125 green screen, two page, func. keys	APX-D125G	675.00
Ampex Dialouge 125 amber screen, two page, func. keys	APX-D125A	685.00
Wyse 50, 14" green phosphor	WYS-50	595.00
Wyse 100, horz & vert. split screen, metal enclosure	WYS-100	795.00
Wyse 300, Eight color display, split screen	WYS-300	1159.00
Televideo 910 Plus, block mode	TVI-910P	575.00
Televideo 925, detatchable keyboard, 22 function keys	TVI-925	759.00
Televideo 950, graphic char. split screen, 22 func	TVI-950	950.00
Televideo 970, 14" green screen, 132 column, European	TVI-970	1095.00
Zenith 29 terminal, VT52 compatible, detatchable keyboard	ZTH-Z29	765.00

APPLE

$929



Apple II/e, 64K computer only	APL-2E	$989
Apple II/e starter kit, monitor, disk, 80 col. card	APL-2ESK	1365
Advanced Busness Tech. 13 Key Pad	ABT-13B	109
Calif. Computer 7710A Async. Serial Interface	CCS-7710	125
Calif. Computer 7710B same but for modem	CCS-7710B	125
Calif. Computer 7114A 12K PROM module	CCS-7114	99
Calif. Computer 7720A parallel interface	CCS-7720	99
Calif. Computer 7724A Calandar/clock modual	CCS-7724	99
Calif. Computer 7729A Centronics interface	CCS-7729	99
Calif. Computer 7740A programmable timer	CCS-7740	99
California Digital 16K card for standard Apple II	CAL-A16	39
Hayes Micromodem II for Apple II	HYS-MM2	279
Kensington Micro, System saver fan	KEN-SF1	75
Microsoft Softcard with CP/M; Z-80	MSF-SFTCD	239
Mountain Computer "The Clock"	MTN-TCLK	225
Mountain Computer AD/DA 16 input, 8bit	MTN-ADDA	269
Mountain Computer ROM Plus with keybd. filter	MTN-RMF	169
Mountain Computer ROM writer/socket socket	MTN-ROMW	139
Orange Micro "GRAPPLER" parallel interface	OMS-G2	135
Sorrento Valley 8" controller double side D/D.	SVA223	395
TEAC 5¼" disk drive for Apple II	TEA-A2	269
Vista Vision 80; 80 column card for std. Apple II	VSA-VIS80	289
Vista 8" disk controller double side D/D.	VSA-A800	389

ASCII KEYBOARD $49



California Digital has purchased over 3000 of these Microswitch keyboards from the General Dynamics Corporation. 93 ASCII encoded Hall effect switches includes 8 function keys and 14 key numeric cluster make this keyboard an excellect value at only $49. MIC-93GD 5 lbs
We also have available a matching General Dynamics steel trim panel. $10

Non-encoded Hytek 58 key metal contact keyboard. HIK-58 $24.95. Matching 15 key numeric cluster $9.95 HIK-15. Both for only $29.95 HIK-5815

Not pictured, 49 key eight bit modified Hollerith coded Microswitch Hall effect keyboard REMOVED from punch card equipment. $14.95 DIT-KB49. ASCII encoder available

256 KILOBYTE MEMORY BOARD

$495

- 256 kilobytes of memory using 64K dynamic RAM.
- Over one megabyte of memory using the new 256K dynamic RAM chips.
- Error detection-trap capability.
- Individual 16K block can be relocated to any boundry within a megabyte of RAM.
- 24 bit addressing and phantom mode capability.

The California Digital 256K RAM board represents an outstanding value in S-100 memory technology. Priced slighty above earlier generation 64K dynamic ram boards it gives you these additional features. 256K of memory with parity. Parity error feature can be jumpered to any of the interrupt lines, a status port, ERROR LED, or IEEE-696 *ERROR signal. 24 or 16 bit addressing with memory management.
Proper operation with front panel equipped systems, DMA disk controllers, and IEEE-696 Temporary Buss Masters assured with an on the board M1 generator for memory refresh timing. CAS and RAS timing is controlled with tapped digital delay lines for proper operation over the entire operating temperature range.
The board is very recent in design using the National Semiconductor DP-8409 RAM Controller chip. Split termination networks are used on all address lines, CAS line, and RAS lines eliminating the last traces of ringing. The board uses two separate voltage regulators. One for the DRAMs and one for the interface logic increasing the noise immunity of the ram array. Typical power dissipation is 8 watts.
Documentation includes theory of operation, configuration guide, a schematic, and application notes on the use of the memory management options. CAL-256K 2 Lbs

S-100 BOARDS

16 BIT MICROPROCESSORS

Octagon dual CPU 8088/Z80, & controller	OCT-88Z80	795.00
Godbout 8086/8087 microcomp. 16 bit	GBT-8687	495.00
Godbout dual processor 8085/8088, 8/16	GBT-8588	359.00

SINGLE BOARD COMPUTERS

Insight EQ-4, 128K, 4 serial "not S-100"	INS-EQ4	595.00
Advanced Digital, Floppy & 64K	AMD-Z80	750.00
Teletek System master, 765 floppy 64K	TEL-SM1	895.00
Teletek FDC-1 single board no memory	TEL-FDC1	675.00

8 BIT MICROPROCESSORS

Godbout Z80, 24 bit extended add	GBT-Z80	250.00
California Computer Z80 microprocessor	CCS-2810	275.00
Tarbell Z80 with two RS232 ports	TAR-Z80	339.00

FLOPPY DISK CONTROLLERS

Godbout Disk 1, double density	GBT-DSK1	395.00
California Computer 2422A with CPM	CCS-2422	339.00
Morrow Disk Jockey II with CPM 2.2	MDS-DJ2	350.00
Morrow Disk Jockey I with CPM, sgl. Den.	MDS-DJ1	225.00
Tarbell Electronics double density	TAR-DDC	419.00
Tarbell Electronics single density	TAR-SDC	279.00
Fulcrum DMA OmniDisk, I/O to hard disk	FCM-OD1	389.00

CPM OPERATING SYSTEM

Digital Research CP/M 3.0, 8" sgl. den	DRC-CpM30	249.00
Godbout CPM 2.2 for Disk 1	GBT-CpM22	159.00
Godbout CPM86 for 8088 and 8086	GBT-CpM86	265.00
Tarbell Electronics CPM 2.2	TAR-CpM22	159.00

HARD DISK CONTROLLERS

Octagon hard disk controller with E/C	OCT-HD1	475.00
Godbout Disk 2, 8" & 14" hard disk	GBT-DSK2	569.00
Godbout Disk 3, for 5¼" Winchesters	GBT-DSK3	Nov.
Morrow Designs controller for 5¼" Win.	MDS-W506	495.00
Western Digital new WD-1001 (not S-100)	WDI-1001	495.00

EPROM BOARDS

Inner Access EPROM Bd. programs 27128	IAC-P100	465.00
Digital Research PROM board, 32K	DGR-P32	119.00

STATIC MEMORY BOARDS

Godbout Ram 16, 64K, 16 bit data trans.	GBT-R16	459.00
Godbout Ram 17, 64K 8 bit 24 bitaddress	GBT-R17	359.00
Godbout Ram 21, 128K byte 8/16 transfer	GBT-R21	859.00
Fulcrum OmniRam 8/16 transfer bank	FCM-R816	395.00
California Computer 2116, 8 bit only	CCS-2116	249.00

DYNAMIC MEMORY BOARDS

California Digital 256K expand to 1 Meg	CAL-D256	495.00
California Comp. 2066, 64K bank select	CCS-2066	295.00

INTERFACE BOARDS

Godbout Interfacer I, 2 serial ports	GBT-133A	239.00
Godbout Interfacer II, 1 serial 3 par'l ports	GBT-150A	269.00
Godbout Interfacer III, with 5 serial ports	GBT-135A	495.00
Godbout Interfacer III, with 8 serial ports	GBT-138A	585.00
Godbut Interfacer IV, 3 serial, 2 parallel	GBT-187A	329.00
California Computer 2710, 4 serial ports	CCS-2710	279.00
California Computer 2719, 2 serial, 2 par'l	CCS-2719	295.00
California Computer 2720, 4 port par'l	CCS-2720	219.00
California Computer 2830, 6 port serial	CCS-2830	429.00
Morrow Designs Multiboard 3 S/2P	MDS-MTL1	319.00

SPECIAL FUNCTION BOARDS

Hayes S-100 Micromodem, 300 baud	HYS-M100	325.00
QT Computer clock calendar, battery	QTC-CC100	139.00
Godbout System support board, 4K EPROM	GBT-SYS1	350.00
Godbout System support board, 9511 math	GBT-S9511	539.00
Dual Systems 4 channel 12 bit D/A conv.	DSC-AOM12	619.00
Dual System 12 bit resolution, 32 ch. A/D	DSC-AIM12	629.00
Mullins Opto-Isolator, controls 8 ch	MUL-ICB10	179.00
Mullins extender board with logic & probe	MUL-TB4	79.00
I/O Technology wire wrap prototype	IOT-W100	49.00
Artec Electronics wire wrap prototype	ART-WW100	25.00
Artec Electronics general purpose solder	ART-GP100	25.00

MAINFRAMES & MOTHER BOARDS

Eclipse Data, stainless, 22 slot	EDP-100	695.00
Godbout Enclosure 2, 20 slots	GBT-MF2D	675.00
California Computer 2200, 12 slot	CCS-2200	479.00
California Digital 18 slot mother board	CAL-MB18	35.00
Godbout 12 slot mother board assembled	GBT-MB12	149.00

CP/M SOFTWARE

AdaSoft CP/M	ADA-445C	395.00
D-Base II	ASH-015C	429.00
Wordstar	MPR-187C	309.00
Mailmerge	MPR-392C	169.00
Spellstar	MPR-429C	169.00
Multiplan	MSF-483C	189.00
Macro 80	MSF-187C	139.00
Supersoft	MPR-309C	149.00
MAC	DGR-401C	85.00
CP/M 3.0	DGR-410C	249.00
Despool	DGR-367C	45.00
Pascal Plus	DGR-004C	429.00
CP/M 86	DGR-186C	239.00
MP/M II	DGR-208C	379.00

Additional Software available for Apple, IBM/PC and Atari. Please telephone for price and availability.



**Shipping: First five pounds $3.00, each additional pound $.50.
Foreign orders: 10% shipping, excess will be refunded.
California residents add 6½% sales tax. • COD's discouraged.
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TECHNICAL & CALIFORNIA
(213) 643-9001**

PRIORITY ONE ELECTRONICS

UNBEATABLE SANYO COMPUTER





12" 80 x 24 18MHz MONITORS

Part Number	Description	List Price	SALE PRICE
BBSYODM8012CX	Black & White Display	$240.00	$149
BBSYODM9012CX	B & W w/audio	$260.00	$165
BBSYODM8112CX	Green P31 Display	$240.00	$149
BBSYODM9112CX	Green P31 w/audio	$260.00	$165
BBSYODM8212CX	Amber Display	$240.00	$149
BBSYODM9212CX	Amber w/audio	$260.00	$165

13" RGB COLOR MONITORS w/AUDIO

BBSYODM6500	Medium Res. 350 x 350 lines	$495.00	$349
BBSYODM7500	High Res. H480 x U240 dots	$725.00	$499
BBSYODM8500	Ultra High H690 x V240 dots	$1085.00	$799

Shipping weights on above monitors: 12" 24 lbs. ea., 13" color 30 lbs. ea.



GEMINI 10X & 15X
120 CPS DOT MATRIX PRINTER

BBSTRGEM10X	80 column (20 lbs.)	$399.00	$289
BBSTRGEM15X	132 column (26 lbs.)	$649.00	$419
BBSTRSERINTX	Serial Interface for 10X and 15X		$ 59
BBSTRSERINTX4K	w/4K print buffer for 10X and 15X		$119

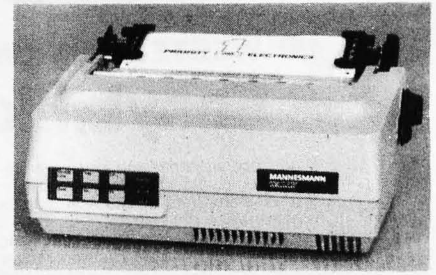
DELTA 10 & 15 160 CPS DOT MATRIX PRINTERS WITH 8K PRINT BUFFER

BBSTRDELTA10	80 column (20 lbs.)	$649.00	$469
BBSTRDELTA15	132 column (20 lbs.)	$799.00	$699

PRINTER CABLES

BBPGC36CP72CP	Centronics Male to Male 6'	$24.95
BBPGC25DP72CP	IBM PC™ to Centronics Parallel 6'	$34.95
BBPGC251P6P	6' 9 conductor shielded RS-232	$19.95

MANNESMANN TALLY



Letter Quality Dot Matrix Printer

For Complete Specifications, see page 41 of our new '83/'84 Engineering Selection Guide

BBTALMT160L	80 column/160 cps (21 lbs.)	$589
BBTALMT180L	132 column/160 cps (28 lbs.)	$829
BBTALMTRIB160	Replacement Ribbon for MT160L	$15.75
BBTALMTRIB180	Replacement Ribbon for MT180L	$17.80

Order Interface Cables at Left

PIXY 3 PLOTTER

High Quality, economical 3 color plotter. See page 37 of our '83/'84 Engineering Selection for details.

BBTALPIX3P	w/parallel interface (sh. wt. 16 lbs.)	$699
BBTALPIX3S	w/serial interface (sh. wt. 16 lbs.)	$769

CompuPro The World's Largest Supplier of S-100 Boards!

CPU BOARDS

Part Number	Description	List Price	Sale Price
BBGBT51068	CPU 68K A&T 8MHz	$ 695.00	$ 595.00
BBGBT51568	CPU 68K CSC 10MHz	$ 850.00	$ 765.00
BBGBT51086	Co-Processor w/8086 only A&T	$ 750.00	$ 675.00
BBGBT51586	Co-Processor w/8086 only CSC	$ 850.00	$ 765.00
BBGBT51067	CPU 8086/8087 A&T	$1050.00	$ 939.00
BBGBT51567	CPU 8086/8087 CSC	$1150.00	$1065.00
BBGBT51080	CPU 8085/88 A&T	$ 495.00	$ 389.00
BBGBT51580	CPU 8085/88 CSC	$ 595.00	$ 497.87
BBGBT51060	3/6MHz CPU-Z A&T	$ 325.00	$ 279.00
BBGBT51560	3/6MHz CPU-Z CSC	$ 425.00	$ 347.87

DISK CONTROLLER BOARDS

BAPDB171ACPM	DISK 1 (A&T) w/CP/M® 2.2	$670.00	$489.00
	When purchased with two 8" disk drives:		$450.00
BBGBT54018	DISK 1 Floppy controller (A&T)	$495.00	$425.00
BBGBT41000	CP/M® 2.2 for Z80/8085 w/manuals & BIOS. 8" S/D Disk		$148.95
BBGBT41050	CP/M-86® for CPU 8085/88 & CPU 8086/87 CPUs w/manuals. BIOS 8" S/D Disk		$249.00
BBGBT54025	DISK 2 8" hard disk controller w/CP/M® 2.2 (A&T)	$795.00	$725.00
BBGBT54030	DISK 3 ST-506 type 5¼" hard disk controller w/CP/M-80® & CP/M-86® (A&T)	$795.00	$725.00

I/O BOARDS

BBGBT56010	System Support 1 Multifunction I/O (A&T)	$450.00	$375.00
BBGBT56010/56531	SS1 w/8231 Math Chip A&T	$645.00	$570.00
BBGBT56010/56320	SS1 w/8232 Math Chip A&T	$645.00	$570.00
BBGBT53030	Interfacer 3 - 8 port serial (A&T)	$699.00	$599.00
BBGBT53040	Interfacer 4 - 3 Serial, 1 Centronics Parallel, 1 Parallel (A&T)	$450.00	$389.00

8/16 BIT MEMORY BOARDS

BBGBT52016	RAM 16 12MHz 32K Static A&T	$ 550.00	$ 495.00
BBGBT52021	RAM 21 12 MHz 128K Static A&T	$ 995.00	$ 895.00
BBGBT52022	RAM 22 12MHz 256K Static A&T	$1750.00	$1549.00
BBGBT52012	M-Drive/H 512K RAM Disk A&T	$1475.00	$1195.00

MAINFRAMES

BBGBT51200	20 Slot Desk Top (A&T)	$925.00	$795.00
BBGBT51250	20 Slot Rack Mount (A&T)	$975.00	$850.00

For more CompuPro Specifications see pages 2-33 of our New Catalog — Vector

Manufactured by Vector Electronic Co. under license from CompuPro

BBVCT8800GFB	Interfacer 1, 2-Serial (A&T)	$295.00	$219.00
BBVCT8800GF2B	Interfacer 2, 3-Par., 1-Ser (A&T)	$325.00	$239.00
BBVCT8800GR17B	RAM 17 64K 10MHz Static RAM (A&T)	$450.00	$389.00

SDSYSTEMS
A SYNTECH COMPANY

Part Number	Description	List Price	SALE Price
BBSDS38095	SBC-300 4MHz Z80A CPU A&T	$ 741.00	$ 619.00
BBSDS38092	SBC-300 6MHz Z80B CPU A&T	$ 825.00	$ 689.00
BBSDS38007	Z80 Starter System A&T	$ 450.00	$ 399.00
BBSDS38088	ExpandoRAM IV 256K A&T	$1145.00	$ 975.00
BBSDS38089	ExpandoRAM IV 256K w/EDC A&T	$1990.00	$1675.00
BBSDS38097	ExpandoRAM III/696 256K	$ 825.00	$ 749.00
BBSDS38076	PROM-100 w/software A&T	$ 285.00	$ 219.00
BBSDS38082	RAM Disk 256K A&T	$ 875.00	$ 775.00
BBSDS38081	ROM Disc 128K A&T	$ 350.00	$ 319.00
BBSDS38096	I/O-8 4-Port Async Ser. A&T	$ 600.00	$ 549.00
BBSDS38098	I/O-8 8-Port Async Ser. A&T	$ 695.00	$ 589.00
BBSDS38094	I/O-8 4 Sync, 4 Async, 8-Port Serial I/O A&T	$ 795.00	$ 699.00
BBSDS38099	Versafloppy III Floppy & ST-506 Hard Disk Controller	$ 895.00	$ 759.00
BBPDBVF339145*	w/5¼" unbanked CP/M® 3.0	$1083.00	$ 888.00
BBPDBVF339146*	w/8" unbanked CP/M® 3.0	$1083.00	$ 888.00
BBPDBVF339147*	w/5¼" banked CP/M® 3.0	$1083.00	$ 888.00
BBPDBVF339148*	w/8" banked CP/M® 3.0	$1083.00	$ 888.00
BBSDS38093	Versafloppy II/696 (A&T)	$ 400.00	$ 344.00
BBPDBVF239141*	w/5¼" unbanked CP/M® 3.0	$ 588.00	$ 424.00
BBPDBVF239142*	w/8" unbanked CP/M® 3.0	$ 588.00	$ 424.00
BBPDBVF239143*	w/5¼" banked CP/M® 3.0	$ 588.00	$ 424.00
BBPDBVF239144*	w/8" banked CP/M® 3.0	$ 588.00	$ 424.00

*CP/M-Plus™ (3.0) configured for the SBC-300

See Complete Specifications on Pages 12-25 Of Our '83/'84 Engineering Selection Guide



BOARD LEVEL PRODUCT

BBOCTCPU816	8/16 Bit SBC (A&T)	$ 895.00	$ 795.00
BBOCT8087NDP	8087 for CPU 8/16		$ 300.00
BBOCTCPM86	CP/M-86®		$ 150.00
BBOCTCONCPM86	Concurrent CP/M-86®		$ 195.00
BBOCTMPM86	MP/M-86®		$ 495.00
BBOCTHDC	ST-506 Hard Disc Controller	$ 595.00	$ 525.00
BBOCTHDSUB19	19.2Mb Hard Disc Subsystem	$2295.00	$1995.00
BBOCTS256TOD	256K Static RAM (A&T)	$1850.00	$1719.00
BBOCTD512K	512K Dynamic RAM (A&T)	$1450.00	$1345.00

See Specifications on Pages 12-27 Of Our '83/'84 Engineering Selection Guide

COMPLETE OCTAGON 8/16™ SYSTEMS

BBOCT816SMPM	w/256K Static RAM & MP/M-86™	$7350.00
BBOCT816SCCPM	w/256K Static RAM & Concurrent CP/M-86	$7350.00
BBOCT816DMPM	w/512K Dynamic RAM & MP/M-86	$7350.00
BBOCT816DCCPM	w/512K Dynamic RAM & Concurrent CP/M-86	$7350.00

See Complete Specifications on Page 5 Of Our New '83/'84 Engineering Selection Guide

Z80 SINGLE BOARD COMPUTERS — ADVANCED DIGITAL CORPORATION

Part Number	Description	List Price	SALE Price
BBADCSUP6128	Super Six 6MHz 128K Master w/1 ADC PS1 RS232 Serial Adapter	$995.00	$849.00
BBADCSPRSLV6128	Super Slave 6MHz 128K	$695.00	$595.00
BBADCSBC15	Super Quad for 5¼" drives	$750.00	$695.00
BBADCSBC18	Super Quad for 8" drives	$750.00	$695.00

SOFTWARE & I/O PORT ADAPTERS

BBADCPS1	PS/Net1 RS232 Serial Adapter	$ 35.00
BBADCCPSP	Centronics Parallel Port Adapter	$ 35.00
BBADCCPM22*†	Advanced Digital CP/M® 2.2	$150.00
BBADCCPM30*†	Advanced Digital CP/M Plus™ (3.0)	$350.00
BBADCTDOS4U*†	TurboDos® 1, 2, or 4 Multi-user	$550.00

*Replace * with **Q** to specify Super Quad; **S** for Super Six
† Replace † with **8** for 8" IBM® 3740 format, **48** for 5¼" 48 TPI format or **96** for 5¼" 96 TPI format.

ST506/SA1000 HARD DISK CONTROLLER

BBADCHDC10015	ST506 5¼" Winchester Cont.	$500.00	$450.00
BBADCHDC10018	8" Winchester Cont.	$500.00	$450.00
BBADCHDCINSTL	Install program for use with non-ADC CPU board (Supplied on 8" CP/M® compatible disk)		$ 10.00

See Complete Specifications on Pages 14 - 27 of our '83/'84 Engineering Selection Guide

MACROTECH International Corp.



MAX: 1 S-100 SLOT 1 MEGABYTE

The MACROTECH MAX is a 256K to 1 Megabyte S-100 IEEE/696 dynamic memory board. That's right, up to 1 Megabyte on a single standard size S-100 board. The first 384K is on the Host card that plugs into your motherboard. The remaining 640K is on a unique "piggy-back" card that attaches to the host. The MAX family is ideally suited to applications where density, speed, and software flexibility are essential.

See Page 16 Of Our New '83/'84 Engineering Selection Guide for Complete Specifications

Ordering Information: The 256K and 384K versions include the fully socketed Host card. The 512K and larger versions also include the fully socketed "piggy-back" card.

		List Price	SALE Price
BBMACMAX256	256K Dynamic RAM (A&T)	$1125.00	$1165.00
BBMACMAX384	384 Dynamic RAM (A&T)	$1467.00	$1395.00
BBMACMAX512	512K Dynamic RAM (A&T)	$1880.00	$1795.00
BBMACMAXM	1 MEG Dynamic RAM (A&T)	$2449.00	$2325.00
BBMACMAXTM	MAX Technical Manual		$ 15.00
BBMACMAXVDSK	MAX Virtual Disk Software supplies on 8" S/D Disk		$ 25.00
BBMACM3	Memory Mapping Option		$ 91.00

Attention CompuPro CPU 8085/88 Users: You must order the CPU modification hardware to insure complete compatibility.

BBMACGBTMOD	Hardware modification for CompuPro CPU 8085/88	$ 10.00



ORDER TOLL FREE (800) 423-5922 - CA, AK, HI CALL (818) 709-5111

Circle 303

PRIORITY ONE ELECTRONICS

DEAL, PAGES 392 & 393

DISK DRIVES & CABINETS ON SALE!!



5¼" FLOPPY DISK DRIVES

BBMPI51*	MPI Full Height SS 48TPI (5 lbs.)	$200.00
BBMPI52*	MPI Full Height DS 48TPI (5 lbs.)	$270.00
BBMPI91*	MPI Full Height SS 96TPI (5 lbs.)	$275.00
BBMPI92*	MPI Full Height DS 96TPI (5 lbs.)	$400.00
BBMPI501	MPI ½-Height SS 48TPI (4 lbs.)	$260.00
BBMPI502	MPI ½-Height DS 48TPI (4 lbs.)	$300.00
BBTNDTM1001	Tandon Full Height SS 48TPI	$199.00
BBTNDTM1002	Tandon Full Height DS 48TPI	$249.00
BBTNDTM1014	Tandon Full Height DS 96TPI	$339.00

*Replace with **M** for MPI Door, or **S** for Shugart SA400 Type Door

5¼" Disk Drive Cabinets

BBJMR1C5	Single Drive Cabinet (5 lbs.)	$ 79.00
BBJMR2C5	Dual Drive Cabinet (9 lbs.)	$ 99.00
BBJMR2C5C	Dual w/Internal Data Cable (9 lbs.)	$115.00

8" Floppy Disk Drives

BBSHU801R	Shugart Full Height SS (18 lbs.)	$349.00
BBSHU851R	Shugart Full Height DS (18 lbs.)	$479.00
BBSIEFDD1008	Siemens Full Height SS (18 lbs.)	$169.00
BBQMETRAK842	Qume Full Height DS (18 lbs.)	$459.00
BBMITM289463B	Mitsubishi Full Height DS (18 lbs.)	$375.00
BBMPI41S	MPI Full Height SS (11 lbs.)	$380.00
BBMPI42S	MPI Full Height DS (11 lbs.)	$460.00
BBMPI41D	MPI Dual ½-Height SS (22 lbs.)	$760.00
BBMPI42D	MPI Dual ½-Height DS (22 lbs.)	$830.00
BBMPI41M	MPI ½-Height SS (9 lbs.)	$380.00
BBMPI42M	MPI ½-Height DS (9 lbs.)	$460.00
BBTNDTM8481	Tandon ½-Height SS (9 lbs.)	$359.00
BBTNDTM8482	Tandon ½-Height DS (9 lbs.)	$435.00

Dual 8" Disk Enclosures

All of these rugged enclosures feature forced, filtered air cooling, hefty power supply, with the heat producing elements mounted to outside for cool, reliable operation. The rear panels are punched for the appropriate data cables.

FDE002. Economical design for two standard size 8" floppies. Hinged lid for easy drive access. Power supply: 5V@4A, -5V@.8A, +24@3A.

DTL002. Cabinet for two ½-height 8" drives or 1 full height 8" floppy or Winchester. Includes Shugart type AC power cable.

Part Number	Description	List Price	SALE Price
BBIIIFDE002	FDE002 Dual Enc. (35 lbs.)	$359.95	$325.00
BBIIIDTL002SHU	DTL002 Dual Thin Line (12 lbs.)	$225.00	$175.00
BBIIIDTLMPIKIT	MPI ½-Height DTL adapter kit		$ 24.95
BBIIICBLSQN304FM	Shugart to Qume AC Cable		$ 4.95

BUY CABINETS WITH DRIVES AND SAVE!

Combinations with FDE002

BBPDBIIIFDE2S2	w/2 SHU801R Drives	$ 969.00
BBPDBIIIFDE2M2	w/2 MFM289463BS Drives	$1049.00
BBPDBIIIFDE2Q2	w/2 QMETRAK842 Drives	$1199.00
BBPDBIIIFDE2851	w/2 SHU851R Drives	$1239.00
BBPDBIIISIE	w/2FDD1008 Drives	$ 595.00

Combinations with DTL002

BBPDBIIITND1	w/2 TNDTM8481 Drives	$ 879.00
BBPDBIIITND2	w/2 TNDTM8482 Drives	$1039.00
BBPDBIIIMPI1	w/2 MPI41M Drives	$ 879.00
BBPDBIIIMPI2	w/2 MPI42M Drives	$1039.00

Due to UPS Regulations, drives and cabinets will be shipped separately. Please include shipping for each disk drive and cabinet.

5¼" Hard Disk

BBMCP1302	Micropolis 20.4/25.9 Mb (12 lbs.)	$1465.00
BBMCP1303	Micropolis 33.9/43.2 Mb (12 lbs.)	$1875.00
BBMCP1304	Micropolis 40.8/51.9 Mb (12 lbs.)	$2195.00
BBTNDTM501	Tandon 6 Mb (9 lbs.)	$ 699.00
BBTNDTM502	Tandon 12 Mb (9 lbs.)	$ 849.00
BBTNDTM503	Tandon 19 Mb (9 lbs.)	$ 995.00

DUAL 5¼" HARD DISK DRIVE CABINET

All of the necessary power for two TANDON TM500 series or equivalent hard disk drives. Just imagine, you can have 100Mbytes of storage using two of the Micropolis 5¼" Winchester disk drives and this cabinet! Power supply: +5V@6A and +12V@6A. The rear panel is punched for two 20, two 34, and one 50 pin header connector. Fan cooled.

BBIIIHD5002	Dual Hard Disk Enclosure	$369.00

BUY CABINET WITH DRIVES AND $AVE!

BBPDB501HD5	w/2 TM501 Drives	$1599.00
BBPDB502HD5	w/2 TM502 Drives	$1899.00
BBPDB503HD5	w/2 TM503 Drives	$2149.00
BBPDB1302HD5	w/2 MCP1302 Drives	$2999.00
BBPDB1303HD5	w/2 MCP1303 Drives	$3799.00
BBPDB1304HD5	w/2 MCP1304 Drives	$4399.00

Due to UPS Regulations, disk drives will be shipped separately from cabinets. Don't forget to include shipping for each disk drive cabinet.

maxell®

IT'S WORTH IT!



5¼" DOUBLE DENSITY DISKETTES

Part Number	Sectors	Tracks	Sides/Heads	Price Per Box of 10: 1	2 or more
BBMXLMD1M	Soft	40	1	$28.00	$25.00
BBMXLMH110M	10 hard	40	1	$28.00	$25.00
BBMXLMH116M	16 Hard	40	1	$28.00	$25.00
BBMXLMD2DM	Soft	40	2	$42.00	$38.00
BBMXLMH210DM	10 Hard	40	2	$42.00	$38.00
BBMXLMH216DM	16 Hard	40	2	$42.00	$38.00
BBMXLMD1DDM	Soft	80	1	$36.00	$33.00
BBMXLMD2DDM	Soft	80	2	$44.00	$40.00
BBMXLMH216DDM	16 Hard	80	2	$44.00	$40.00

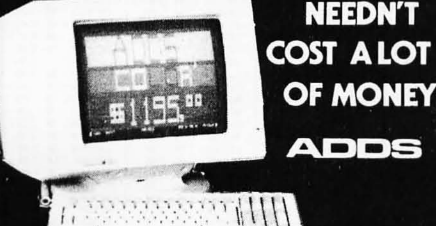
All mini disks with exception of MD1DDM, MD2HD, & MD2DDM are with hub ring

8" DOUBLE DENSITY DISKETTES

BBMXLFD1126M1200	Soft	1	$36.00	$33.00
BBMXLFH132M1200	Hard	1	$36.00	$33.00
BBMXLFD2XDM1200	Soft	2	$45.00	$40.00
BBMXLFH232DM1200	Hard	2	$45.00	$40.00

Go on The Gold Standard!

A GOOD COLOR TERMINAL NEEDN'T COST A LOT OF MONEY



ADDS

BBADDCOLOR Viewpoint/Color Terminal (40 lbs.) List: $1295.00

ON SALE NOW FOR ONLY: $1129.00

1200 BAUD MODEM SALE

For more details on Modems, see pages 38 & 39 of our New Catalog



AUTO DIAL/ AUTO ANSWER

FREE SOFTWARE!

Part Number	Description	List Price	SALE
BBPDBPASSTEL8	Password Modem w/Communication Software 8" CP/M™	$528.00	$379.00
BBPDBPASSTEL5	Password Modem w/Communication Software 5¼" Apple	$528.00	$379.00
BBPDBADIALTEL8	Auto Dial 212A Modem w/Communication Software 8" CP/M®	$678.00	$$495.00
BBPDBADIALTEL5	Auto Dial 212A Modem w/Communication software 5¼" Apple	$678.00	$495.00
BBPDBS100TEL8	S-100 Modem Card w/operating software on 8" CP/M® diskette	$528.00	$379.00

D.C. HAYES

Part Number	Description	List Price	Our Price
BBDCH0400P	1200 Baud Smartmodem	$695.00	$514.95
BBDCH0200P	300 Baud Smartmodem	$279.00	$229.00
BBDCH0300P	Chronograph	$249.00	$199.00
BBDCH0100P	MicroModem 100	$399.00	$349.00
BBDCH0000P	MicroModem II	$379.00	$299.00
BBDCH1200B	IBM-PC™ Modem card	$599.00	$499.00

RIXON

1200 Baud Direct Connect w/10 Number Memory

BBRIXR212A	1200 Baud Stand Alone unit	$495.00	$449.00
BBRIXPC212A	1200 IBM PC™ modem (2 lbs.)	$495.00	$449.00
BBRIXPCCOM1	IBM PC™ Modem Software (1 lb.)		$ 89.00
BBPDBRIXIBM	IBM Modem & Software Together (3 lbs.)		$539.00

HITACHI DUAL TRACE SCOPES

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40MHz with Delay Line
BBHITV422 List Price: $895.00
SALE PRICE: $749.00
(Shipping Weight: 17 lbs.)

60MHz with Trigger View
BBHITV650F List Price: $1195.00
SALE PRICE: $995.00
(Shipping Weight: 31 lbs.)

100MHz Delayed Sweep/ Quad Trace
BBHITV1050F List Price: $1595.00
SALE PRICE: $1395.00
(Shipping Weight: 31 lbs.)

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RETAIL STORE PHONE NUMBERS: (Chatsworth:) (818) 709-5464 - (Irvine:) (714) 660-1411

7400

**Number of Pins of each I.C. for easy Socket purchase

Part No.	**Pins	Price
SN7400N	14	.25
SN7401N	14	.25
SN7402N	14	.25
SN7403N	14	.25
SN7404N	14	.25
SN7405N	14	.25
SN7406N	14	.45
SN7407N	14	.29
SN7408N	14	.25
SN7409N	14	.25
SN7410N	14	.25
SN7411N	14	.25
SN7412N	14	.49
SN7413N	14	.39
SN7414N	14	.49
SN7416N	14	.25
SN7417N	14	.25
SN7420N	14	.19
SN7421N	14	.49
SN7422N	14	.49
SN7423N	16	.59
SN7425N	14	.29
SN7426N	14	.29
SN7427N	14	.25
SN7428N	14	.59
SN7430N	14	.25
SN7432N	14	.29
SN7437N	14	.25
SN7438N	14	.29
SN7439N	14	.59
SN7440N	14	.19
SN7441N	16	.89
SN7442N	16	.45
SN7443N	16	1.25
SN7444N	16	1.25
SN7445N	16	.69
SN7446N	16	.69
SN7447N	16	.69
SN7448N	16	.69
SN7450N	14	.19
SN7451N	14	.19
SN7453N	14	.19
SN7454N	14	.19
SN7459N	14	.25
SN7460N	14	.39
SN7470N	14	.29
SN7472N	14	.29
SN7473N	14	.35
SN7474N	14	.35
SN7475N	16	.45
SN7476N	16	.35
SN7479N	14	4.95
SN7480N	14	.89
SN7482N	14	1.49
SN7483N	16	.59
SN7485N	16	.59
SN7486N	14	.35
SN7489N	16	2.25
SN7490N	14	.39
SN7491N	14	.79
SN7492N	14	.39
SN7493N	14	.39
SN7494N	14	.89
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	3.25
SN74100N	24	1.95
SN74104N	14	1.19
SN74105N	14	1.19
SN74107N	**14**	**.29**
SN74109N	**16**	**.39**
SN74116N	24	1.49
SN74121N	14	.39
SN74122N	14	.69
SN74123N	16	.49
SN74125N	14	.45
SN74126N	14	.45
SN74132N	14	.49
SN74136N	14	.69
SN74141N	16	.89
SN74142N	16	3.95
SN74143N	24	3.95
SN74144N	24	3.95
SN74145N	16	.59
SN74147N	16	1.49
SN74148N	16	1.19
SN74150N	24	1.19
SN74151N	16	.59
SN74152N	14	.59
SN74153N	16	.59
SN74154N	24	1.25
SN74155N	16	.59
SN74156N	16	.59
SN74157N	**16**	**.59**
SN74160N	16	.69
SN74161N	16	.69
SN74162N	16	.69
SN74163N	16	.69
SN74164N	14	.69
SN74165N	16	.69
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SN74167N	16	2.95
SN74170N	16	1.29
SN74172N	24	4.95
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SN74368N	16	.55
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74LS

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74LS162	16	.69
74LS163	16	.69
74LS164	14	.69
74LS165	16	1.19
74LS168	16	1.19
74LS169	16	1.19
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.69
74LS175	16	.69
74LS181	24	2.95
74LS190	16	.89
74LS191	16	.89
74LS192	16	.79
74LS193	16	.79
74LS194	16	.69
74LS195	16	.69
74LS197	14	.79
74LS221	16	.89
74LS240	20	1.09
74LS241	20	1.09
74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.49
74LS245	20	1.49
74LS247	16	1.09
74LS248	16	1.09
74LS249	16	1.09
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.69
74LS273	20	1.49
74LS279	16	.49
74LS283	16	.69
74LS290	14	.89
74LS293	14	.79
74LS298	16	.89
74LS352	16	1.29
74LS353	16	1.29
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.49
74LS374	20	1.49
74LS375	16	.69
74LS386	14	.45
74LS393	14	1.19
74LS399	16	1.49
74LS670	16	1.49
81LS95	20	1.49
81LS97	20	1.49

74S/PROMS*

74S00	14	.35
74S02	14	.35
74S03	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.39
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S38	14	.89
74S40	14	.39
74S51	14	.35
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S85	16	2.49
74S86	14	.55
74S112	16	.55
74S113	14	.55
74S114	14	.55
74S133	16	.45
74S134	16	.50
74S135	16	.69
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.55
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.49
74S174	16	1.19
74S175	16	1.19
74S188*	16	1.49
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	2.25
74S241	20	2.25
74S242	14	2.49
74S243	14	2.49
74S244	20	2.49
74S251	16	1.19
74S253	16	1.19
74S257	16	1.19
74S258	16	1.19
74S260	14	1.19
74S280	14	1.95
74S287*	16	1.95
74S288*	16	1.95
74S373	20	2.49
74S374	20	2.49
74S387*	16	1.95
74S471*	20	5.95
74S472*	20	4.95
74S473*	20	4.95
74S474*	24	4.95
74S475*	24	4.95
74S570*	16	2.95
74S571*	16	2.95
74S572*	18	4.95
74S573*	18	4.95
74S940	20	2.49
74S941	20	2.49

CA—LINEAR

CA3010H		1.35
CA3039H		1.35
CA3046N	14	1.35
CA3059N	14	2.95
CA3060N	16	2.95
CA3065E	14	1.49
CA3080E	8	.89
CA3081N	16	.99
CA3082N	16	1.19
CA3083N	16	1.49
CA3086N	14	.69
CA3089N	16	1.69
CA3096N	16	1.49
CA3130E	8	.89
CA3140E	8	.79
CA3160H		1.95
CA3161E	16	2.95
CA3162E	16	6.95
CA3189E	16	1.59
CA3401N	14	.59

CD—CMOS

CD4000	14	.29
CD4001	14	.29
CD4002	14	.29
CD4006	14	1.19
CD4007	14	.29
CD4009	16	.59
CD4010	16	.59
CD4011	14	.29
CD4012	14	.29
CD4013	14	.39
CD4014	16	1.19
CD4015	16	.39
CD4016	14	.49
CD4017	16	1.19
CD4018	16	.99
CD4019	16	.59
CD4020	16	1.19
CD4021	16	1.19
CD4022	16	1.19
CD4023	14	.29
CD4024	14	.69
CD4025	14	.23
CD4026	16	2.49
CD4027	16	.45
CD4028	16	.69
CD4029	16	1.29
CD4030	14	.39
CD4034	24	2.49
CD4035	16	1.49
(More in Catalog)		
CD4040	16	1.19
CD4041	14	1.19
CD4042	16	.89
CD4043	16	.79
CD4044	16	.79
CD4046	16	1.19
CD4047	14	1.29
CD4048	16	.59
CD4049	16	.39
CD4050	16	.39
CD4051	16	.99
CD4052	16	.99
CD4053	16	.99
CD4056	16	2.95
CD4059	24	7.95
CD4060	16	1.49
CD4066	14	.59
CD4068	14	.39
CD4069	14	.29
CD4070	14	.39
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4075	14	.29
CD4076	16	1.19
CD4078	14	.49
CD4081	14	.29
CD4082	14	.29
CD4093	14	.49
CD4098	16	1.95
CD4506	16	1.19
CD4507	14	1.19
CD4508	24	3.95
CD4510	16	1.29
CD4511	16	1.19
CD4512	16	1.19
CD4514	24	2.49
CD4515	24	2.49
CD4516	16	1.19
CD4518	16	1.19
CD4519	16	.59
CD4520	16	1.19
CD4526	16	1.49
CD4528	16	1.49
CD4529	16	1.69
CD4543	16	1.95
CD4562	14	6.95
CD4566	16	1.39
CD4583	16	2.49
CD4584	14	.69
CD4723	16	1.19
CD4724	16	1.19
MC14409	16	13.95
MC14410	16	13.95
MC14411	24	11.95
MC14412	16	13.95
MC14419	16	7.95
MC14433	24	13.95
MC14538	16	1.19
MC14541	14	1.19

MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS

Part No.	**Pins	Function	Price
CDP1802	40	CPU	$2.95
MCS6502	40	MPU w/Clock	5.95
MCS6502B	40	MPU w/Clock at 3MHz	9.95
6809	40	CPU—8-bit (Internal Clock) 1MHz	14.95
6809E	40	CPU—8-bit (External Clock) 1MHz	14.95
INS8035N-6	40	MPU—8-bit (6MHz)	5.95
INS8039N	40	CPU-Sgl. chip 8-bit (128bts. Ram)	5.95
INS8040N-6	40	CPU (256 bytes RAM)	9.95
INS8070N	40	CPU (64 bytes RAM)	29.95
INS8073N	40	CPU w/Basic Micro Interpreter	29.95
P8085A	40	CPU	4.95
8086	40	CPU 16-bit 5MHz	24.95
8088	40	CPU 8/16-bit	29.95
8155	40	HMOS RAM I/O Port-Timer	6.95
8748	40	HMOS EPROM MPU	24.95

Z80, Z80A, Z80B, Z8000 SERIES

Z80	40	CPU (MK3880N)(780C) 2MHz	$3.95
Z80-CTC	28	Counter Timer Circuit	3.95
Z80-DART	40	Dual Asynchronous Rec./Trans.	10.95
Z80-DMA	40	Direct Memory Access Circuit	9.95
Z80-P10	40	Parallel I/O Interface Controller	3.95
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	12.95
Z80-S10/1	40	Serial I/O (Lacks DTRB)	12.95
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80-S10/9	40	Serial I/O	12.95
Z80A	40	CPU (MK3880N-4)(780C-1) 4MHz	4.49
Z80A-CTC	28	Counter Timer Circuit	4.95
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-P10	40	Parallel I/O Interface Controller	3.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB bonded)	12.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	12.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80A-S10/9	40	Serial I/O	12.95
Z80B	40	CPU (MK3880N-6) 6MHz	9.95
Z80B-CTC	28	Counter Timer Circuit	12.95
Z80B-DART	40	Dual Asynch. Receiver/Transmitter	19.95
Z80B-P10	40	Parallel I/O Interface Controller	12.95
Z8001	48	CPU Segmented	44.95
Z8002	40	CPU Non-Segmented	34.95
Z8030	40	Serial Comm. Controller	44.95
Z8036	40	Counter/Timer & Parallel I/O Unit	29.95

6500/6800/68000 SERIES

MC6502A	40	MPU with clock and RAM (2MHz)	6.95
MC6520	40	Peripheral Inter. Adapter	4.95
MC6800	40	MPU	2.95
MC6802CP	40	MPU with clock and RAM	7.95
MC6809E	40	CPU (1MHz) External (Locking)	14.95
MC6821	40	Peripheral Inter. Adapt (MC6820)	2.95
MC6828	24	Priority Interrupt Controller	15.95
MC6830L8	24	1024x8-bit ROM (MC68A30-8)	9.95
MC6850	24	Asynchronous Comm. Adapter	3.95
MC6852	24	Synchronous Serial Data Adapter	5.75
MC6860	24	0-600bps Digital MODEM	7.95
MC68000L8	64	MPU 16-Bit (8MHz)	49.95
MC68488P	40	General Purpose Int. Adapter	9.95
MC68652P2	40	Multi. Protocol Comm. Controller	24.95
MC68661PB	28	Enhanced Prog. Comm. Int.	9.95
MCM68764	24	64K EPROM (450ns)	24.95
SY6522	40	Peripheral Inter. Adapter	7.95

8080A SERIES

INS8080A	40	CPU	2.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
8156	40	RAM with I/O Port and Timer	6.95
INS82C06	20	Octal D Flip Flop Tri-State (74C374)	2.49
DP8212	24	8-bit Input/Output (74S412)	2.25
DP8214	24	Priority Interrupt Control	2.95
DP8216	16	Bi-Directional Bus Driver	1.95
DP8224	16	Clock Generator/Driver	2.25
DP8226	16	Bus Driver	2.25
DP8228	28	System Cont./Bus Driver (74S428)	3.49
DP8238	28	System Controller (74S438)	4.49
INS8243	24	I/O Expander for 48 Series	3.95
INS8245	18	16-Key Keyboard Encoder (74C922)	4.49
INS8246	20	20-Key Keyboard Encoder (74C923)	4.95
INS8247	28	Display Controller (74C911)	8.95
INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm. Element	10.95
DP8251	28	Prog. Comm. I/O (USART)	4.49
DP8253	24	Prog. Interval Timer	6.95
DP8255	40	Prog. Peripheral I/O (PPI)	4.49
DP8257	40	Prog. DMA Control	5.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	8.95
DP8303	20	8-Bit Tri-State Bi-Directional Trans.	3.95
DP8304	20	8-bit Bi-Directional Receiver	2.95
DP8307	20	8-bit Bi-Directional Receiver	2.95
DP8308	20	8-bit Bi-Directional Receiver	2.95
DP8310	20	Octal Latched Peripheral Driver	4.95
8741	40	8-bit Univ. Peripheral Interface	29.95
8755	40	16K EPROM with I/O	24.95

DISK CONTROLLERS

INS1771-1	40	Single Density	16.95
FD1791	40	Single/Dual Density (Inv.)	29.95
FD1793	40	Single/Double Density (True)	29.95
FD1795	40	Dual Density/Side Select (Inv.)	29.95
FD1797	40	Dual Density/Side Select True	29.95
6843P	40	Floppy Disk Controller (1MHz)	29.95

SPECIAL FUNCTION

DS0025CN	8	Dual MOS Clock Driver (5MZ)	2.49
DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
INS2651	28	Communication Chip	8.95
MC3470P	18	Floppy Disk Read Amp System	4.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	7.95
COP402N	40	Microcontroller w/64-digit RAM and Direct LED Drive	5.95
COP402MN	40	Microprocessor w/64-digit RAM & Direct LED Drive w/N Buss Int.	5.95
COP470N	20	32-seg VAC Fluor. Drvr. (20-pin pkg.)	3.25
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

DYNAMIC RAMS

Part No.	**Pins	Function	Price
1103	18	1024x1 (300ns)	.99
4027	**16**	**4096x1 (250ns)**	**2.49**
4116N-2	16	16,384x1 (150ns)	1.89 - 8/14.95
4116N-3	16	16,384x1 (200ns)	1.69 - 8/12.95
4116N-4	16	16,384x1 (250ns)	1.49 - 8/10.95
4164N-150	16	65,536x1 (150ns)	6.95 - 8/49.95
4164N-200	16	65,536x1 (200ns)	5.95 - 8/44.95
MM5261	18	1024x1 (300ns)	.49 - 8/1.95
MM5262	**22**	**2048x1 (365ns)**	**.49 - 8/1.95**
MM5270	18	4096x1 (250ns) MK4096	4.95
MM5280	22	4096x1 (200ns) 2107	3.95
MM5290-2	16	16,384x1 (150ns)	1.89 - 8/14.95
MM5290-3	16	16,384x1 (200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1 (250ns)	1.49 - 8/10.95
MM5298-3	16	8192x1 (200ns)	1.69

STATIC RAMS

1101	16	256x1 (650ns)	1.49
2101	22	256x4 (450ns) 8101	2.49
2102	16	1024x1 (350ns)	.89
21L02	16	1024x1 (450ns) L.P.	1.49
2111	18	256x4 (450ns) 8111	2.95
2112	16	256x4 (450ns) MOS	1.95
2114	18	1024x4 (450ns)	1.49 - 8/9.95
2114L	18	1024x4 (450ns) L.P.	1.95 - 8/13.95
2114-2	18	1024x4 (200ns)	1.75 - 8/11.95
2114L-2	18	1024x4 (200ns) L.P.	2.25 - 8/14.95
2147	18	4096x1 (70ns)	4.95
2148	18	1024x4 (70ns)	4.95
TMS4045	18	1024x4 (450ns)	3.95
TMS40L47-45	20	1024x4 (450ns)	2.95
5101	22	256x4 (450ns) CMOS	2.95
MM5257	18	4096x1 (450ns) 4044	4.95
HM6116P-3	24	2048x8 (150ns) CMOS	5.95
HM6116-4	24	2048x8 (200ns) CMOS	4.95
HM6116LP-4	24	2048x8 (200ns) L.P. CMOS	5.49
HM6264P-15	28	8192x8 (150ns) CMOS	39.95
27LS00	16	256x1 (80ns) L.P.	9.95
7489	16	16x4 (50ns) 3101	2.25
74C920	22	256x4 (250ns)	3.95
74C921	18	256x4 (250ns) CMOS	3.95
74C929	16	1024x1 (250ns) CMOS (6501)	3.95
74C930	18	1024x1 (250ns) CMOS (6518)	3.95
74S189	16	16x4 (35ns) 93405	1.95
74S200	16	256x1 (80ns) 93410	3.95
74S206	16	256x1 (60ns) 93411	3.95
74S289	16	16x4 (35ns) 3101	2.25
82S10	16	1024x1 (50ns) O.C. (93415)	3.95
82S25	16	16x4 (50ns) O.C. (74S289)	2.25

PROMS/EPROMS

1702A	24	256x8 (1us)	4.95
2708	24	1024x8 (450ns)	3.95
2708-5	24	1024x8 (550ns) SM00246	2.95
TMS2516	24	2048x8 (450ns) 2716	5.95
TMS2532	24	4096x8 (450ns) NMC2532	6.95
TMS2564	28	8192x8 (450ns)	14.95
TMS2716	24	2048x8 (450ns) 3 voltage	9.95
2716	24	2048x8 (450ns)	4.95
2716-1	24	2048x8 (350ns)	5.95
2716Q-5	24	2048x8 (550ns)	4.49
2732	24	4096x8 (450ns)	6.95
2732A-3	24	4096x8 (300ns)	7.95
2732A-4	24	4096x8 (450ns) 21V	6.95
2732Q-4	24	4096x8 (550ns)	5.95
2758Q-A	24	1024x8 (450ns)	2.95
2764-4	28	8192x8 (450ns)	9.95
2764-3	28	8192x8 (300ns)	14.95
MM5204Q	24	512x8 (1us)	4.95
MCM68764	24	8192x8 (450ns)	24.95
27128	28	16,384x8 (450ns) 128K EPROM	59.95
74S188	16	32x8 PROM O.C. (6330-1)	1.49
74S287	16	256x4 PROM T.S. (6301-1)	1.95
74S288	16	32x8 PROM T.S. (6331-1)	1.95
74S387	16	256x4 PROM O.C. (6300-1)	1.95
74S471	20	256x8 PROM T.S. (6309-1)	5.95
74S472	20	512x8 PROM T.S. (6349-1)	4.95
74S473	20	512x8 PROM O.C. (6348)	4.95
74S474	24	512x8 PROM T.S. (DM87S296N)	4.95
74S475	24	512x8 PROM O.C. (6340)	4.95
74S476	18	1024x4 PROM T.S.	6.95
74S478	24	1024x8 PROM T.S.	8.95
74S570	16	512x4 PROM O.C. (6305)	2.95
74S571	16	512x4 PROM T.S. (6306)	2.95
74S572	18	1024x4 PROM O.C. (6352)	4.95
74S573	18	1024x4 PROM T.S. (82S137)	4.95
82S23	16	32x8 PROM O.C. (27S18)	2.95
82S115	24	512x8 PROM T.S. (27S15)	9.95
82S123	16	32x8 PROM T.S. (27S19)	2.95
82S126	16	256x4 PROM O.C. (27S20)	2.95
82S129	16	256x4 PROM T.S. (27S21)	2.95
82S130	16	512x4 PROM O.C. (27S12)	3.95
82S185	18	2048x4 PROM T.S. (TBP24S81)	9.95
82S190	24	2048x8 (80ns)	14.95
82S191	24	2048x8 (80ns)	14.95
DM87S180N	24	1024x8 PROM O.C. (82S180)	9.95
DM87S181N	24	1024x8 PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4 PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4 PROM T.S. (82S185)	9.95
DM87S190N	24	2048x4 PROM O.C. (82S190)	14.95
DM87S191N	24	2048x8 PROM T.S. (82S191)	14.95

DATA ACQUISITION

DC10		Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0807LCN)	1.49
MC1408L8	18	8-bit D/A Converter (DAC0808LCN)	2.25
ADC0803LCN	20	8-bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-bit A/D Converter (1LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
ADC0817	40	8-bit A/D Converter (16-Ch. Multi.)	9.95
DAC1000	24	10-bit D/A Conv. Micro. Comp. (0.05%)	7.95
DAC1008	20	10-bit D/A Conv. Micro. Comp. (0.20%)	6.95
DAC1020	16	10-bit D/A Conv. (0.05% Lin.)	7.95
DAC1022	16	10-bit D/A Conv. (0.20% Lin.)	5.95
DAC1222	18	12-bit D/A Conv. (0.20% Lin.)	6.95
LM334Z		Constant Current Source	1.19
LM335Z		Temperature Transducer	1.40
LM399H		Temp. Comp. Prec. Ref. (.5ppm/C°)	5.00
AY-5-1013A	**40**	**30K Baud Uart (TR1602)**	**3.95**

LOW PROFILE (TIN) SOCKETS

	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
36 pin LP	.46	.42	.39
40 pin LP	.49	.46	.43

SOLDERTAIL (GOLD) STANDARD

	1-9	10-99	100-up
8 pin SG	.30	.27	.25
14 pin SG	.43	.39	.37
16 pin SG	.47	.43	.41
18 pin SG	.53	.49	.47
24 pin SG	.69	.65	.61
28 pin SG	.81	.76	.72
36 pin SG	1.09	1.03	.97
40 pin SG	1.21	1.14	1.08

LP

SG

ST

WW

SOLDERTAIL STANDARD (TIN)

	1-9	10-99	100-up
14 pin ST	.29	.27	.25
16 pin ST	.34	.32	.30
18 pin ST	.38	.36	.34
20 pin ST	.45	.43	.41
24 pin ST	.49	.46	.43
28 pin ST	.69	.67	.63
40 pin ST	.99	.95	.89

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-9	10-99	100-up
8 pin WW	.49	.45	.42
10 pin WW	.65	.62	.59
14 pin WW	.65	.62	.59
16 pin WW	.69	.65	.61
18 pin WW	.89	.85	.79
20 pin WW	1.09	1.05	.99
22 pin WW	1.25	1.19	1.15
24 pin WW	1.29	1.23	1.18
28 pin WW	1.59	1.50	1.45
36 pin WW	1.85	1.75	1.69
40 pin WW	1.99	1.89	1.79

$10.00 Minimum Order — U.S. Funds Only
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1355 SHOREWAY ROAD, BELMONT, CA 94002

2/84 ***PHONE ORDERS WELCOME — (415) 592-8097 Telex: 176043***

Digitalker™

DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc.

The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. Female and children's voices can be synthesized. The vocabulary is chosen so that it is applicable to many products and markets.

The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

DT1050 Digitalker™ . . . . $34.95 ea.
MM54104 Processor Chip . . . . $14.95 ea.

DT1057 - Expands the DT1050 vocabulary from 137 to over 260 words. Includes 2 ROMs and specs.
Part No. DT1057 . . . . $24.95 ea.

INTERSIL

** Evaluation Kits*

Part No.	**Pins	Function	Price
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit*	28	Stopwatch Chip, XTL	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	9.95
FE0203D		3½ Digit LCD Display for 7106 & 7116	19.95
7106EV/Kit*	40	IC, Circuit Board, Display	34.95
7107CPL	40	3½ Digit A/D (LED Drive)	11.95
7107EV/Kit*	40	IC, Circuit Board, Display	29.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD	16.95
7201IUS		Low Battery Volt Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	24	Stopwatch Chip, XTL	14.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit*	16	Tone Generator Chip, XTL	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit*	14	Freq. Counter Chip, XTL	7.95
7215IPG	24	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	24	4 Func. Stopwatch Chip, XTL	14.95
7216AIJI	28	8 Digit Univ. Counter C.A.	29.95
7216CIJI	28	8 Digit Freq. Counter C.A.	24.95
7216DIPI	28	8 Digit Freq. Counter C.C.	19.95
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	11.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	10.95
7226AIJL	40	8 Digit Univ. Counter	29.95
7226AEV/Kit*	40	5 Function Counter Chip, XTL	74.95

30009 1983 INTERSIL Data Book (1356p.) $9.95

NEW PRODUCT! 74HC High Speed CMOS

74HC00	14	.59
74HC02	14	.59
74HC03	14	.75
74HC04	14	.59
74HCU04	14	.65
74HC08	14	.59
74HC10	14	.59
74HC11	14	.59
74HC14	14	.85
74HC20	14	.59
74HC27	14	.59
74HC32	14	.75
74HC42	16	.99
74HC51	14	.75
74HC58	14	.75
74HC73	14	.79
74HC74	14	.79
74HC75	16	.89
74HC76	16	.79
74HC85	16	1.59
74HC86	14	.69
74HC107	14	.79
74HC109	16	.79
74HC112	16	.79
74HC113	14	.79
74HC132	14	.99
74HC137	16	1.95
74HC138	16	1.09
74HC139	16	.99
74HC147	16	1.19
74HC151	16	.89
74HC153	16	.99
74HC154	24	2.49
74HC157	16	.89
74HC158	16	.89
74HC160	16	1.29
74HC161	16	1.29
74HC162	16	1.29
74HC163	16	1.29
74HC164	14	1.29
74HC165	16	2.79
74HC173	16	1.69
74HC174	16	.99
74HC175	16	.99
74HC192	16	1.39
74HC193	16	1.39
74HC194	16	1.09
74HC195	16	1.09
74HC237	16	2.95
74HC240	20	1.95
74HC241	20	1.95
74HC242	14	1.95
74HC243	14	1.95
74HC244	20	1.95
74HC245	20	2.49
74HC251	16	.89
74HC253	16	.99
74HC257	16	.89
74HC259	16	1.49
74HC266	14	1.19
74HC273	20	2.89
74HC280	14	3.95
74HC373	20	2.39
74HC374	20	2.39
74HC390	16	1.49
74HC393	14	1.49
74HC533	20	2.39
74HC534	20	2.39
74HC595	16	3.95
74HC688	20	3.19
74HC4002	14	.59
74HC4017	16	2.19
74HC4020	16	1.39
74HC4024	14	1.59
74HC4040	16	1.39
74HC4060	16	1.39
74HC4075	14	.59
74HC4078	14	.69
74HC4511	16	2.69
74HC4514	24	3.79
74HC4538	16	2.39
74HC4543	16	3.49

74HCU04 is unbuffered. All others are buffered.

NEW Programmable Array Logic (PALS)

Part No.	**Pins	Function	Price
PAL10H8	20	Octal 10-Input AND-OR Gate Array (High Output)	$3.95
PAL12H6	20	Hex 12-Input AND-OR Gate Array (High Output)	3.95
PAL14H4	20	Quad 14-Input AND-OR Gate Array (High Output)	3.95
PAL10L8	20	Octal 10-Input AND-OR-Invert Gate Array (Low Output)	3.95
PAL12L6	20	Hex 12-Input AND-OR-Invert Gate Array (Low Output)	3.95
PAL14L4	20	Quad 14-Input AND-OR-Invert Gate Array (Low Output)	3.95
PAL16L8	20	Octal 16-Input AND-OR-Invert Gate Array	9.95
PAL16R8	20	Octal 16-Input Register AND-OR Gate Array	7.95
PAL16R6	20	Hex 16-Input Register AND-OR Gate Array	7.95
PAL16R4	20	Quad 16-Input Register AND-OR Gate Array	7.95

30012 1982 NATIONAL PAL Data Book (176p.) . . $5.95

74C—C/MOS

74C00	14	.35
74C02	14	.35
74C04	14	.29
74C08	14	.35
74C10	14	.35
74C14	14	.69
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.39
74C48	16	1.95
74C73	14	.79
74C74	14	.69
74C85	16	1.95
74C86	14	.39
74C89	16	5.95
74C90	14	1.19
74C93	14	1.19
74C95	14	1.39
74C107	14	.89
74C151	16	2.49
74C154	24	3.49
74C157	16	2.25
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.49
74C173	16	1.19
74C174	16	1.19
74C175	16	1.19
74C192	16	1.49
74C193	16	1.69
74C195	16	1.39
74C221	16	1.95
74C240	20	1.95
74C244	20	1.95
74C373	20	2.49
74C374	20	2.49
74C901	14	.59
74C903	14	.59
74C906	14	.59
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.69
80C97	16	.69

LINEAR

TL071CP	8	.79
TL072CP	8	1.39
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM301CN	8	.35
LM302H		1.95
LM304H		1.95
LM305H		.99
LM307CN	8	.45
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.75
LM311CN	8	.69
LM312H		2.49
LM317T		1.19
LM317K		3.95
LM318CN	8	1.95
LM319N	14	1.95
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320T-5		.89
LM320T-12		.89
LM320T-15		.89
LM323K		5.95
LM324N	14	.59
LM337T		1.95
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340T-5		.79
LM340T-12		.79
LM340T-15		.79
LF347N	14	1.49
LM348N	14	.99
LM350K		4.95
LF355N	8	1.10
LF356N	8	1.10
LM370N	14	4.49
LM373N	14	3.95
LM377N	14	1.95
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.39
LM384N	14	1.79
LM386N-3	8	.89
TL494CN	16	3.95
TL496CP	8	1.19
NE531V	8	2.95
NE544N	14	2.95
NE550A	14	1.95
NE555V	8	.35
LM556N	14	.69
NE564N	16	2.95
LM565N	14	1.19
LM566CN	8	1.49
LM567V	8	.99
NE570N	16	3.95
LM703CN	8	1.19
LM709N	14	.49
LM710N	14	.69
LM711N	14	.79
LM723N	14	.55
LM733N	14	1.00
LM739N	14	1.95
LM741CN	8	.35
LM747N	14	.69
LM748N	8	.59
LM1310N	14	1.49
LM1458CN	8	.59
LM1488N	14	.89
LM1489N	14	.89
LM1496N	14	1.95
LM1800N	16	2.49
LM1871N	18	2.95
LM1872N	18	3.25
LM1877N-9	14	2.49
LM1889N	18	2.25
LM1896N	14	2.95
LM2002T		1.95
LM3189N	16	1.59
LM3900N	14	.59
LM3905CN	8	1.19
LM3909N	8	.99
LM3914N	18	2.95
LM3915N	18	2.95
LM3916N	18	2.95
RC4136N	**14**	**1.25**
RC4151NB	8	1.95
RC4194TK		4.49
NE5532	8	2.49
NE5534	8	1.69
ICL8038B	14	3.95
LM13080N	8	1.19
LM13600N	16	1.19

MORE AVAILABLE

30003 1982 Nat. Linear Data Book (1952 pgs.) . $11.95

Circle 192 on inquiry card.

HOME COMPUTER ACCESSORIES

VOICE SYNTHESIZER FOR APPLE AND COMMODORE



JE520AP

JE520CM

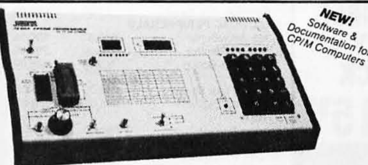
• Over 250 word vocabulary-affixes allow the formation of more than 500 words • Built-in amplifier, speaker, volume control, and audio jack • Recreates a clear, natural male voice • Plug-in user ready with documentation and sample software • Case size: 7¼"L × 3¼"W × 1-3/8"H

APPLICATIONS: • Security Warning • Teaching • Instrumentation • Telecommunication • Handicap Aid • Games

The JE520 VOICE SYNTHESIZER will plug right into your computer and allow you to enhance almost any application. Utilizing National Semiconductor's DIGITALKER(tm) Speech Processor IC (with four custom memory chips), the JE520 compresses natural speech into digital memory, including the original inflections and emphases. The result is an extremely clear, natural vocalization.

Coming Soon: VOCABULARY EXPANSION MODULE
• Expands to over 1000 basic words
• Allows selection of up to 6 additional word sets

Part No.	Description	Price
JE520CM	For Commodore 64 & VIC-20	$114.95
JE520AP	For Apple II, II+, and //e	$149.95



JE664 EPROM PROGRAMMER
8K to 64K EPROMS — 24 & 28 Pin Packages
Completely Self-Contained — Requires No Additional Systems for Operation

• Programs and validates EPROMs • Checks for properly erased EPROMs • Emulates PROMs or EPROMs • RS232C Computer Interface for editing and program loading • Loads data into RAM by keyboard • Changes data in RAM by keyboard • Loads RAM from an EPROM • Compares EPROMs for content differences • Copies EPROMs • Power Input: 115VAC, 60Hz, less than 10W power consumption • Enclosure: Color-coordinated, light tan panels with molded end pieces in mocha brown • Size: 15⅝"L x 8¾"D x 3½"H • Weight: 5¾ lbs.

The JE664 EPROM Programmer emulates and programs various 8-Bit Word EPROMs from 8K to 64K-Bit memory capacity. Data can be entered into the JE664's internal 8K x 8-Bit RAM in three ways: (1) from a ROM or EPROM; (2) from an external computer via the optional JE665 RS232C BUS; (3) from its panel keyboard. The JE664's RAMs may be accessed for emulation purposes from the panel's test socket to an external microprocessor. In programming and emulation, the JE664 allows for examination, change and validation of program content. The JE664's RAMs can be programmed quickly to all "1"s (or any value), allowing unused addresses in the EPROM to be programmed later without necessity of "UV" erasing. The JE664 displays DATA and ADDRESS in convenient hexadecimal (alphanumeric) format. A "DISPLAY EPROM DATA" button changes the DATA readout from RAM word to EPROM word and is displayed in both hexadecimal and binary code. The front panel features a convenient operating guide. The JE664 Programmer includes one JM16A Jumper Module (as listed below).

JE664-A EPROM Programmer. $995.00
Assembled & Tested (Includes JM16A Module)

JE665 — RS232C INTERFACE OPTION — The RS232C Interface Option implements computer access to the JE664's RAM. This allows the computer to manipulate, store and transfer EPROM data to and from the JE664. A sample program listing is supplied in MBASIC for CP/M computers. Documentation is provided to adapt the software to other computers with an RS232 port. 9600 Baud, 8-bit word, odd parity and 2 stop bits.

FOR A LIMITED TIME A SAMPLE OF SOFTWARE WRITTEN IN BASIC FOR THE TRS-80* MODEL I, LEVEL II COMPUTER WILL ALSO BE PROVIDED.

JE664-ARS EPROM Prog. w/JE665 Option. $1195.00
Assembled & Tested (Includes JM16A Module)

EPROM JUMPER MODULES — The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets the JE664 for the proper programming pulses to the EPROM and configures the EPROM socket connections for that particular EPROM.

JE664 EPROM Jumper Mod. No.	EPROM	Programming Voltage	EPROM MANUFACTURER	PRICE
JM08A	2708	25V	AMD, Motorola, Nat., Intel TI	$14.95
JM16A	2716, TMS2516 (TI)	25V	Intel, Motorola, Nat., NEC, TI, AMD, Hitachi, Mostek	$14.95
JM16B	TMS2716 (3-V's)	-5V,+5V,+12V	Motorola, TI	$14.95
JM32A	TMS2532	25V	Motorola, TI, Hitachi, OKI	$14.95
JM32B	2732	25V	AMD, Fujitsu, NEC, Hitachi, Intel, Mitsubishi, National	$14.95
JM32C	2732A	21V	Fujitsu, Intel	$14.95
JM64A	MCM68764, MCM68L764	21V	Motorola	$14.95
JM64B	2764	21V	Intel, Fairchild, OKI	$14.95
JM64C	TMS2564	25V	TI	$14.95

4-Digit Fluorescent Alarm Clock Kit

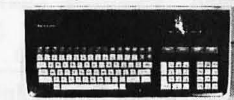


• Bright 4-digit 0.5" high display • 10 minute snooze alarm • AM/PM indicator • Automatic display dimmer

The JE750 Clock Kit is a versatile 12-hour digital clock with 24-hour alarm. The clock has a bright 0.5" high blue-green fluorescent display. The display will automatically dim with changing light conditions. The 24-hour alarm allows the user to disable the alarm and immediately re-enable the alarm to activate 24 hours later. The kit includes all documentation, components, case and wall transformer. Size: 6⅝"L x 3¼"W x 1¾"D.

JE750 Alarm Clock Kit. $29.95

KEYBOARDS — POWER SUPPLIES


21⅞"L x 9.8"W x 3⅛"H

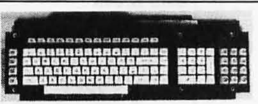
106-Key 8-Bit Serial ASCII Keyboard
• Numeric and cursor keypad • 10 user definable keys • 7 LED function displays • Security lock • N-key rollover • Color: white with black panel • Documentation included • Weight: 6½ lbs.

KB139. . . . . $59.95


19⅞"L x 7⅛"W x 1½"H

Micro-Switch 106-Key Keyboard 8-Bit Serial ASCII
• Numeric and cursor keypad • 8 user definable keys • Japanese/English characters • 8 LED function displays • Documentation incl. • Fits DTE-22 enclosure • Wt: 3½ lbs.

KB106SD29-4. . . . . $29.95


19¾"L x 6½"W x 1½"H

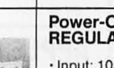
SMK 103-Key Unencoded Keyboard
Numeric and cursor keypad • SPST mechanical keyswitches • 40-pin header connection • Fits DTE-22 enclosure • Weight: 3½ lbs.

KB9000. . . . . $19.95



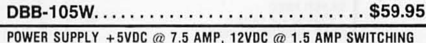
Power/Mate Corporation REGULATED POWER SUPPLY
• Input: 105-125/210-250VAC at 47-63 Hz • Output: 5VDC @ 3.0 Amps/6VDC @ 2.5 Amps • Size: 4⅞"L x 4"W x 2⅛"H • Weight: 2 lbs.

EMA5/6B. $29.95



Power/Mate Corporation REGULATED POWER SUPPLY
• Input: 105-125/210-250VAC at 47-63 Hz • Output: 5V @ 6 amps/6V @ 5 amps • Size: 5⅝"L x 4⅞"W x 2⅞"H • Weight: 4 lbs.

EMA5/6C. $39.95



Power-One's REGULATED POWER SUPPLY
• Input: 105-125VAC, 47-440 Hz • Output: +5V @ 12 amp; +12V @ 1.7 amp; -12V @ 1.7 amp • Size: 14.25"L x 4.87"W x 2.75"H • Weight: 11 lbs.

DBB-105W. $59.95



POWER SUPPLY +5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING
Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp. Fan volt./power supply select switches (115/230VAC). Output: 5VDC @ 7.6 amp, 12VDC @ 1.6 amp. 8 ft. blk. pow. cord. 11½''W x 13¼''D x 3¾''H. Wt. 6 lbs.
Part No. PS94VOS . . . . $39.95 each



POWER SUPPLY 4-Channel Switching - Apple Compatible
Microprocessor, mini-computer, terminal, medical equipment and process control applications. Input: 90-130VAC 47-440Hz. Output: +5VDC @ 5A, -5VDC @ 1A; +12VDC @ 1A, -12VDC @ 1A. Line reg.: ±0.2%. Ripple: 30mV p-p. Load reg.: ±1%. Overcurrent protection. Adj: 5V main output ±10%. 6-3/8"L x 1-7/8"W x 4-15/16"H. Wt. 1½ lbs.
Part No. FCS-604A . . . . $69.95 each

DISKETTES AND ACCESSORIES



5¼" and 8" Diskettes
SSDD = Single Sided Double Density DSDD = Double Sided Double Density
SSQD = Single Sided Quad Density DSQD = Double Sided Quad Density

ULTRA MAGNETICS — 5¼" DISKETTES

Part No.	Description	Boxed	PRICE
UM51401	5¼" SSDD Soft Sector with Hub Ring and Envelope	10	$24.95
UM00096	5¼" SSDD Soft Sector with Hub Ring (Bulk)	100	169.95
UM52401	5¼" DSDD Soft Sector with Hub Ring and Envelope	10	32.95
UM00140	5¼" DSDD Soft Sector with Hub Ring (Bulk)	100	239.95
UM51801	5¼" SSQD Soft Sector with Envelope (96TPI)	10	34.95
UM00214	5¼" SSQD Soft Sector 96TPI (Bulk)	100	259.95
UM52801	5¼" DSQD Soft Sector with Envelope (96TPI)	10	41.95
UM00217	5¼" DSQD Soft Sector 96TPI (Bulk)	100	299.95

SK (ESKEI) — 5¼" DISKETTES

Part No.	Description	Boxed	PRICE
SK1D	5¼" SSDD Soft Sector with Hub Ring and Envelope	10	20.95
SK1DB	5¼" SSDD Soft Sector with Hub Ring (Bulk)	100	149.95
SK2D	5¼" DSDD Soft Sector with Hub Ring and Envelope	10	26.95
SK2DB	5¼" DSDD Soft Sector with Hub Ring (Bulk)	100	199.95

ULTRA MAGNETICS — 8" DISKETTES

Part No.	Description	Boxed	PRICE
UM81726	8" SSSD IBM-Compatible (128 B/S, 26 Sectors) and Envelope	10	34.95
UM00825	8" SSSD IBM-Compatible (128 B/S, 26 Sectors) Bulk	100	239.95
UM82726	8" DSDD Soft Sector (Unformatted) with Envelope	10	49.95
UM00840	8" DSDD Soft Sector (Unformatted) Bulk	100	299.95

All diskettes listed above are soft-sectored. All have Hub Rings with the exception of the Quad Density and the 8" Series.

DISKETTE ACCESSORIES

Disk Minder
• Attractive, functional disk storage system • 50 (8") or 75 (5¼") disk storage capacity • Easy filing and retrieving • Protects disk from dust contamination • Molded from durable smoked plastic with front carrying handle • Size: 7"W × 6½"H × 9¼"D • Weight: 2 lbs.

Part No.	Description	Price
DM75	Stores 75 (5¼") Diskettes	$19.95 each
DM50	Stores 50 (8") Diskettes	$29.95 each

MINI-PAK
• Stores 10 (5¼") diskettes • Protects disk from dust contamination • Durable smoked plastic • Size: 6"L × 5⅞"H × 1⁷⁄₁₆"D

Part No.	Description	Price
MP-10	Stores 10 (5¼") Diskettes	$2.95 each

Diskette Envelopes
Sleeves for Bulk-Purchased Diskettes
• Tear proof • Lint/contaminant free • Anti-static protect. • Wear resist.

Part No.	Description	Price
MP5201	10 White 5¼" Envelopes	10 for $ 1.49
MP5201-100	100 White 5¼" Envelopes	100 for $10.95
MP8201	10 White 8" Envelopes	10 for $ 1.95
MP8201-100	100 White 8" Envelopes	100 for $17.95

Vinyl Pages
For 3-Ring Binders
Protects disks from dirt, scratches, dust, spills, and other contaminants. Reduces the risk of getting dirt near your disk drive head. Size: 8½" × 11"

Part No.	Description	Price
PC001	2 Pocket 5¼" Vinyl Page	10 for $7.95
PC001-2	4 Pocket 5¼" Vinyl Page	10 for $8.95
PC014	1 Pocket 8" Vinyl Page	10 for $7.95
PC014-2	2 Pocket 8" Vinyl Page	10 for $8.95

Mail Pak™
• Holds up to 3 diskettes
• Ideal for mailing and retail packaging
• Dust proof and durable
• Transparent sleeve allows easy identification

Part No.	Description	Price
MP-05	Holds 3 ea. 5¼" Diskettes	$2.49 each
MP-08	Holds 3 ea. 8" Diskettes	$3.95 each

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DISK DRIVES AND CABLE

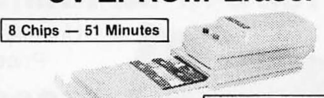
PANASONIC JA551-2
Double-Sided Half-Height 5¼" DRIVE
Shugart SA455 Equivalent
• Single or double density • 48 TPI • 40 tracks • 6ms *track to track* • *327KBytes* formatted storage • One year warranty parts and labor
The JA551 is perfect for word processors, personal and portable computers, small business computers and terminal add-ons. Includes operating manual. Requires: +5VDC @ .9A and +12VDC @ 1 A. Size: 5.88"W x 1.63"H x 8"D. Wt: 3.3 lbs.
JA551-2. . . . . $239.95

TEAC FD55A
Single-Sided Half-Height 5¼" Drive
• Single or double density • 48 TPI • 40 tracks • 6ms track to track • 5W power consumption • Brushless DC direct-drive motor • 160KBytes formatted storage • One year warranty parts and labor
Double your work space with the TEAC 5¼ FLOPPY DISK DRIVE. Because the TEAC FD55A Drive is half the height of conventional drives, you can fit up to four TEAC drives in the same space where two conventional drives fit. Or, have room for two floppy disk drives and a hard disk drive. Includes operating manual. Requires: +5VDC @ .55A and +12VDC @ .3A. Size: 5¾"W x 1⅝"H x 8"D. Wt: 3 lbs.
FD55A. $249.95

SHUGART SA455
Double-Sided Half-Height 5¼" Drive
• Single or double density • 48 TPI • 40 tracks • 409KBytes formatted storage • 6ms track to track • Brushless DC direct-drive motor • One year warranty parts and labor • Media and interface compatible with the SA450
Backed by the Industry's largest and most experienced engineering sales and service organization, the SA455 is the smart solution for a wide range of desktop applications. Includes operating manual. Requires: +5VDC @ .7A and +12VDC @ .75A. Size: 5.88"W x 1.63"H x 8"D. Wt: 3.3 lbs.
SA455. . . . . $259.95

UV-EPROM Eraser

8 Chips — 51 Minutes



1 Chip — 37 Minutes

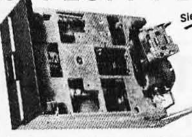
Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

DE-4 UV-EPROM Eraser . . . $79.95
UVS-11EL Replacement Bulb $16.95



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• Uses Shugart SA390 mechanics • 143K formatted storage • 35 tracks — compatible with Apple controller • Complete with connector and cable — just plug into your disk controller card • Size: 6"L × 3½"W × 8-9/16"D • Weight: 4¼ lbs.
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• 400/800K Bytes Capacity
• Industry Standard

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FDD100-8 . . $169.95 ea.

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5¼" DRIVES USE 34-PIN ASSEMBLIES
8" DRIVES USE 50-PIN ASSEMBLIES
*S = SOCKET CONNECTOR
*C = CARD-EDGE CONNECTOR

SINGLE DRIVE CABLE
Style M: *S — 36" — *C
Style N: *S — 60" — *C

Drive	Style	Part No.	1-4	5+
5¼"	M	S34-36-C	7.95	7.25
5¼"	N	S34-60-C	8.95	8.39
8"	M	S50-36-C	10.95	9.95
8"	N	S50-60-C	12.49	10.95

DUAL DRIVE CABLES
Style O: *S — 36" — *C — 18" — *C
Style P: *S — 60" — *C — 24" — *C

Drive	Style	Part No.	1-4	5+
5¼"	O	S34-36C-18C	12.59	11.19
5¼"	P	S34-60C-24C	14.29	12.69
8"	O	S50-36C-18C	16.49	14.49
8"	P	S50-60C-24C	18.95	16.95

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Circle 192 on inquiry card.

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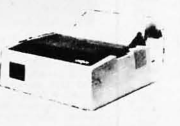
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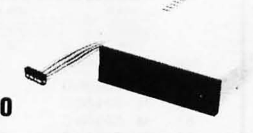
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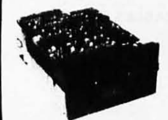
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IBM PC

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P/N MC-064SPC (64K, S, P, C)	395	279
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		339
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P/N SP64, (64K, Clk, S, P)		319
PLANTRONICS Color plus™ Card		469
QUADRAM Quadboard (64-256K)		
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QuadLink Apple Card	680	525
Quadboard 64K		279
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SSM Transmodem 1200		479
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Quadboard 64K		279
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•"PC Extender" (up to 10 I/O)	249	199
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IBM 5¼" SS SD	10/60	43
IBM 5¼" SS DD	10/65	47
VERBATIM 525-01 SS	10/45	23
VERBATIM 550-01 DS	10/55	34
MAXELL MD1 SS	10/50	29
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Keyboard Ext. Cable (3-9')		34
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The Peach (Surge Protector)		68
The Orange (with EMI/RFI)		122
The Lime		76
INTEL 8087 IC		199
KOALA PAD		99
KRAFT Joystick IBM	70	40
RAM EXPANSION		
16K Motherboard (16 IC's)		19
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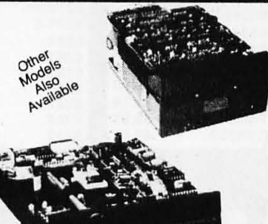
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74LS09	.29	74LS192	.79
74LS10	.25	74LS193	.79
74LS11	.35	74LS194	.69
74LS12	.35	74LS195	.69
74LS13	.45	74LS196	.79
74LS14	.59	74LS197	.79
74LS15	.35	74LS221	.89
74LS20	.25	74LS240	.95
74LS21	.29	74LS241	.99
74LS22	.25	74LS242	.99
74LS26	.29	74LS243	.99
74LS27	.29	74LS244	1.29
74LS28	.35	74LS245	1.49
74LS30	.25	74LS247	.75
74LS32	.29	74LS248	.99
74LS33	.55	74LS249	.99
74LS37	.35	74LS251	.59
74LS38	.35	74LS253	.59
74LS40	.25	74LS257	.59
74LS42	.49	74LS258	.59
74LS47	.75	74LS259	2.75
74LS48	.75	74LS260	.59
74LS49	.75	74LS266	.55
74LS51	.25	74LS273	1.49
74LS54	.29	74LS275	3.35
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74LS86	.39	74LS324	1.75
74LS90	.55	74LS352	1.29
74LS91	.89	74LS353	1.29
74LS92	.55	74LS363	1.35
74LS93	.55	74LS364	1.95
74LS95	.75	74LS365	.49
74LS96	.89	74LS366	.49
74LS107	.39	74LS367	.45
74LS109	.39	74LS368	.45
74LS112	.39	74LS373	1.39
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74LS165	.95	81LS96	1.49
74LS166	1.95	81LS97	1.49
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7402	.19	74126	.45
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7405	.25	74143	4.95
7406	.29	74145	.60
7407	.29	74147	1.75
7408	.24	74148	1.20
7409	.19	74150	1.35
7410	.19	74151	.55
7411	.25	74153	.55
7413	.35	74154	1.25
7414	.49	74155	.75
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7425	.29	74163	.69
7427	.29	74164	.85
7430	.19	74165	.85
7432	.29	74166	1.00
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7442	.49	74173	.75
7445	.69	74174	.89
7446	.69	74175	.89
7447	.69	74177	.75
7448	.69	74181	2.25
7451	.23	74184	2.00
7473	.34	74185	2.00
7474	.33	74191	1.15
7475	.45	74192	.79
7476	.35	74193	.79
7482	.95	74194	.85
7483	.50	74195	.85
7485	.59	74197	.75
7486	.35	74198	1.35
7489	2.15	74221	1.35
7490	.35	74246	1.35
7492	.50	74247	1.25
7493	.35	74259	2.25
7495	.55	74273	1.95
7497	2.75	74276	1.25
74100	1.75	74279	.75
74107	.30	74366	.65
74109	.45	74367	.65
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74121	.29	74393	1.35
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.27						.40
.33						.40
.47				.35		.50
.68						.45
1.0			.40	.40	.45	.45
1.5				.45		.50
1.8						.75
2.2		.35	.40	.45		.65
2.7		.40	.45			.90
3.3		.45	.50	.55	.60	.65
3.9		.45				
4.7	.45	.55		.60	.65	.85
6.8			.70		.75	
8.2						1.00
10	.55	.65	.80	.85	.90	1.00
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27			2.25			
39		1.50				
47	1.35					
56	1.75					
100		3.25				
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47	50V	.05	.0015	50V	.05
56	50V	.05	.0022	50V	.05
68	50V	.05	.005	50V	.05
82	50V	.05	.01	50V	.07
100	50V	.05	.02	50V	.07
220	50V	.05	.05	50V	.07
330	50V	.05	.1	12V	.10
			.1	50V	.12

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4.7	50V	.15	10	50V	.16
10	50V	.15	22	16V	.14
47	35V	.18	47	50V	.20
100	16V	.18	100	15V	.20
220	35V	.20	100	35V	.25
470	25V	.30	150	25V	.25
2200	16V	.60	220	25V	.30
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2N2218	.50	2N3904	.10
2N2218A	.50	2N3906	.10
2N2219	.50	2N4122	.25
2N2219A	.50	2N4123	.25
2N2222	.25	2N4249	.25
PN2222	.10	2N4304	.75
MPS2369	.25	2N4401	.25
2N2484	.25	2N4402	.25
2N2905	.50	2N4403	.25
2N2907	.25	2N4857	1.00
PN2907	.125	PN4916	.25
2N3055	.79	2N5086	.25
3055T	.69	PN5129	.25
2N3393	.30	PN5139	.25
2N3414	.25	2N5209	.25
2N3563	.40	2N6028	.35
2N3565	.40	2N6043	1.75
PN3565	.25	2N6045	1.75
MPS3638	.25	MPS-A05	.25
MPS3640	.25	MPS-A06	.25
PN3643	.25	MPS-A55	.25
PN3644	.25	TIP29	.65
MPS3704	.15	TIP31	.75
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18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
64 pin ST	4.25	call
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14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
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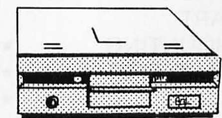
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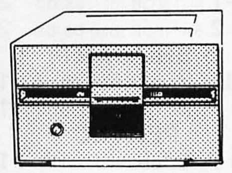
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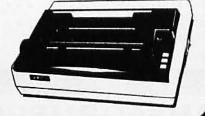
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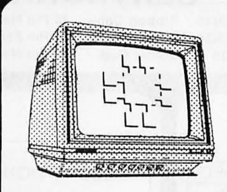
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Unclassified Ads

WANTED: IBM 5100-5120 with APL, 64K, RS-232C serial I/O option. I am developing an adaptive pharmacokinetic system for medical applications. Also, looking for prospective associates and programmers versed in C, APL, or Z80/8086 assembly language. Peter A. Orner, MD, PhD, Suite A-204, 3737 Moraga Ave., San Diego, CA 92117, (619) 272-6781.

WANTED: Tax-exempt, not-for-profit organization seeks computer donation for compilation of reference information on AIDS. Will be used in a network to provide up-to-date information to local AIDS groups. Certified receipts. Paul Paroski Jr., MD, National Gay Health Education Foundation Inc., 114 Willoughby Ave., Brooklyn, NY 11205, (212) 622-3000.

WANTED: Tax-deductible donation of Apple computer, disk-drive, monitor, and/or printer to be used for financial records, membership drives, state and federal yearly reports, updating animal-care sheets, etc. References and IRS information on request. We pay shipping and give receipt. Carol Odell, Wildlife Rescue Team Inc., Route 2, Lincoln, NE 68505.

FOR SALE: Lot 1: *BYTE*: July, November, December, 1977; 1978 to 1981, complete; 1982 and 1983, less two issues. Lot 2: *Kilobaud Microcomputing*: June, September to December, 1977; 1978 to 1980, complete; 1981, less December; 12 issues scattered thru 1982–1983. Lot 3: *Creative Computing* numbers 2, 4, 5, and 6 of 1978; 1979 to 1981, complete; numbers 2, 3, 4, and 12 of 1982; 1983, complete. Will accept best offer FOB for each lot. Duncan Bailey, 609 Echo Glen, River Vale, NJ 07675, (201) 666-3992.

NEEDED: Physically disabled Vietnam Veteran needs Smart-modem for access to college computer from home. Used OK. Irving J. Goldfarb, 116 Court St., Plattsburgh, NY 12901.

FOR SALE: Multiuser CP/M computer, one 60-megabyte Winchester disk drive, one tape backup, expandable to 32 users, floppy and tape backup, demo unit with new guarantee; lists for $32,000, sell for $16,000. Allen Cohen, American Bar Code Systems, Suite 376, 5757 West Century Blvd., Los Angeles, CA (213) 642-1101.

FOR SALE: Morrow Designs MD-3 microcomputer with CP/M, 64K RAM, and two double-sided disk drives. Includes standard software plus lots of extra programs. Used only 4 months: $1300 or best offer. Heath H-29 terminal: $695 firm. Richard Haendel, POB 22152, Oklahoma City, OK 73123, (405) 721-9215.

FOR SALE: ELF computer, not completed with regulated power supply and heavy-duty transformer, enclosure cabinet for computer boards, ASCII keyboard, and monitor. Giant board and I/O board have been tested. Documentation included. Tom Acuff, 3109 15th St., Moline, IL 61265, (309) 764-5977.

FOR SALE: ELF II computer with 4K RAM, giant board, expansion power supply, UHF and VHF video modulators, light pen, various programs, and complete manuals: $250. John Chorlton, 2316 View Ridge Dr., Bellingham, WA 98226, (206) 733-5122.

FOR SALE: DEC computer system. Includes a MINC-11 processor, an RX02 dual 8-inch DSDD floppy-disk drive, a DECwriter III 180-cps printing terminal, and a VT105 video terminal with graphics capability. System comes complete with the MINC BASIC and RT-11 operating systems and includes both FORTRAN and assembly language compilers. May be willing to sell terminals separately. Excellent condition; price negotiable. Herbert Wendell, 405 Northfield Ave., West Orange, NJ 07052, (201) 736-8259.

WANTED: Atari 800 games and other programs on disk. Send name, address, and disk; I'll return a disk with different programs. *Sen Can, 3717 Diamondhead Dr., St. Louis, MO 63125.*

FOR SALE: OSI-C3-A, 56K with dual 8-inch SSSD drives. CP/M package, printer interface, and cable. Lifeboat XBASIC, COBOL, FORTRAN. OS-65D 3.0, OS-65U 1.1, OS-DMSA nucleus, OS-65D extended editor, and Wordstar 3.0. All disks and documentation: $1800. FOB Wilton. Wm. E. Ritchie; RD 2, Wilton, NH 03086, (603) 654-6157.

FOR SALE: Memorex 651 hard-sector 8-inch floppy-disk drive. Used but in good condition. Make offer or will trade for S-100 boards, etc. Kevin Cardon, 1500 North 1220 East, Lehi, UT 84043, (801) 768-9567.

FOR SALE: Four Shugart SA800 8-inch floppy-disk drives in excellent shape: $150 each. Two Memorex 552 8-inch floppy-disk drives, double-sided: $175 each. Roger Wilson, 922 Dunbarton Dr., Richardson, TX 75081, (214) 690-1895 after 6 p.m.

FOR SALE: OSI system consisting of Superboard (mounted in cast-aluminum cover) and Leedex 12-inch monitor, cassette, and ASR 33 teletype. In very good condition with good system documentation. Will sell for best offer or trade for dot-matrix printer. Edward Crovella, (716) 839-3468 after 6 p.m.

FOR SALE: Working S-100 boards. 16K static RAMs: $65 each. 8K static RAMs: $30 each. Bytesaver II with 10 2708s: $75. Processor Tech 1200 bps cassette interface: $35. OP-80 optical paper-tape reader: $20. Two partial SOL-20s: $15 each. Mostly Processor Technology software. Martin Eberhard, 307 East Healey #10, Champaign, IL 61820, (217) 398-0077 evenings.

FOR SALE: Vector Graphics MZ with S-100, Z80, 4MHz, 56K, dual 300K disks, Centronics and RS-232C ports, SOROC 120 terminal, Selectric printer/typewriter, CP/M, Pascal-Z, and other goodies: $2500 or offer. Also, PDP-8M CPU, 8K core, autostart, and I/O interface: $500 as is. TI-59 Calculator with printer-base, all accessories and software, like new: $250. PROM-Blaster Apparat for Apple II: $75. Mike Hughes, POB 393, Rapid City, SD 57709, (605) 341-6755.

FOR SALE: Microtek MT80P printer: $250. Microterm ACT-I terminal: $100. SwTPC 6800 computer with 44K. Two serial and one parallel I/O boards: $425. SwTPC AC30 cassette interface: $50. Send for complete list. Jim Hall, 2063 108th Ave., Otsego, MI 49078, (616) 694-9760.

WANTED: Information on the IBM printer Model 3284-2: serial-interface location on the logic control unit, it's pin definition and location. Would like to interface it to a Z80 microprocessor. Also, would welcome and answer all correspondence related to computers, programming, etc. Tony-A'damse Veerk, 41F The Hague, Holland.

FOR SALE: H-14 printer with RS-232C serial cable; excellent condition, checked by factory. Extra ribbons and all manuals included: $125. Will pay shipping. Tom Dorsett, E 2726 Golden Rd., Spokane, WA 99208, (509) 466-0585.

WANTED: Apple software to swap. Will trade for games, utilities, or whatever. Send typed list of programs and I'll send mine. Wade Tsai, 1309 South Port Blvd., New Iberia, LA 70560, (318) 367-8860.

FOR SALE: Epson MX-100 printer, Epson interface board for Apple, and Graphicwriter: all $600 or best offer. Apple Disk II Drive: $299. Rana Disk Elite One: $250. Versawriter: $199. DOS Toolkit: $40. Gorgon: $27. ABM: $15. Swashbuckler: $20. Other software at varying prices. Peter Su, 14 Devonshire Dr., Barrington, RI 02806.

WANTED: Computer and electronics enthusiasts who want to correspond with a 22-year-old male electronics engineer. I am interested in the exchange of ideas, programs, and circuit designs. I use an S-100, Z80-based system. Also, anybody who wants to communicate about the electronics and computing scene in India. Kim Agrawal, Sri Aurobindo Ashram, Pondicherry 605 002, India.

FOR SALE: Heavy-duty power-supply system. Metal case (12 by 6 by 30), two Lambda power supplies: (LGS-EE-5-OV-R; 5 V @ 110 amps) and (LND-X-152; ±12 V @ 2.5 amps) with AC-power fail-detection board. Package price: $1400; asking $700. Jim Kitchen, (713) 644-2841 days, 251-0723 nights.

FOR SALE: 48K Atari 400 with BASIC cartridge, manual, dust cover, and various cassettes: all for $250. Also, an Atari 16K memory board that I will swap for back issues of BYTE, *Creative Computing*, or *Compute*. Best offer, send your list. Jim W. Prickett, 2142 Cross Rd., El Centro, CA 92243.

FOR SALE: Base II dot-matrix printer in top condition with RS-232C serial, Centronics parallel, 20-mA-current loop, and IEEE-488 interfaces. Also, has tractor feed, graphics, and extended buffer options. Asking $450. Will consider trading for 1200-bps computer, external modem, or item of equal value. Walter Vose Jeffries, HB1630 Dartmouth, Hanover, NH 03755.

FOR SALE: LNW 80 computer board with gold connectors, most capacitors, resistors, and sockets. All manuals and the BYTE construction article: $125 or offer. Also, three S-100 Vector Graphics boards (1977 Rev. 1 & 2) including the hi-res board, 8K RAM board, and the Flash-writer board: all three for $200 or best offer. James E. Shephard, 15634 Northeast 107th Court, Redmond, WA 98052, (206) 883-6052.

WANTED: Schematics and operational information on the Seals Electronics 32KSC, a 32K-byte S-100 static RAM board. Also, for sale: five new, unused boards needing some logic parts and new, prime RAM chips: TI TMS 4044, 4116, 21L02; and 801R-compatible disk drive. Prices negotiable. Steve Fritts, POB 13057, St. Paul, MN 55113, (612) 771-8264.

WANTED: Student would appreciate the donation of an Apple II with disk drive and 64K to be used in the development of educational programs for schools and to further my knowledge of computer languages. Mark Zwich, 1821 Woodsfield Dr., Richfield, WI 53076.

UNCLASSIFIED POLICY: Readers who have computer equipment to buy, sell, or trade or who are requesting or giving advice may send a notice to BYTE for inclusion in the Unclassified Ads section. To be considered for publication, an advertisement must be noncommercial (individuals or bona fide computer clubs only), typed double-spaced on plain white paper, contain 75 words or fewer, and include complete name and address. This service is free of charge; notices are printed once only as space permits. Your confirmation of placement is appearance in an issue of BYTE as we engage in no correspondence. Please allow at least three months for your ad to appear. Send your notices to Unclassified Ads, BYTE/McGraw-Hill, POB 372, Hancock, NH 03449.

FOR SALE: North Star Horizon II, S-100 bus, 32K, dual 5¼-inch drives, RTC, two serial and one parallel ports, oak cabinet, manuals, etc. Lots of software. Offers? Also, two IBM 7441/1980 Selectric ball-communicating printers, financial keyboards, and RS-232C interface. Will include Z80 and/or 6502 software drivers, and documentation: $230 each or $420 for both. FOB. Also, TTY model 43 KSR with modem: $475. Rich Adamson, 7310 Adams, Lincoln, NE 68507, (402) 464-0718.

FOR SALE: Apple II 48K computer (has full uppercase and lowercase keyboard), 16K language card, disk drive with controller and green monitor: $1000 or best offer. Also, MX-80 friction-feed kit: $70. Lester Bartel, 1907 Barham, Dodge City, KS 67801, (316) 227-7536.

WANTED: I am interested in corresponding with other Cromemco C-10 owners, users, and groups to share and swap programs and information. Steven E. Martin, 7751 Gamid Dr., Springfield, VA 22153, (703) 664-4251 days and 451-2992 evenings.

FOR SALE: Okidata Microline 80: $195. IDS 440G: $345. Okidata Slimline 160: $1195. Decis Data 6540: $995. Mountain Apple Clock: $145. Apple Parallel Card: $70. Apple Communicate Card: $115. visual V200 CRT: $545. Microfinesse Fin Model (new): $290. Panasonic NV8200 VCR: $550. All clean, in working condition, manuals included. Dave Drucker, 5 Norbert, Hawthorn Woods, IL 60047, (312) 541-2122.

FOR SALE: Tektronix 60-MHz dual trace, delayed-alternate time-base oscilloscope, Model 2215 with accessory pouch: like new: $1000 or best offer. Stephen Rao, 9001 Watertown Plank Rd., Milwaukee, WI 53226, (414) 257-8567.

FOR SALE: OSI C4P, MF, 48K RAM, two 5-inch disk drives, battery backup clock/calendar, four joysticks, programmable tone generator, DAC, 32 by 64 redefinable character or graphic in 16 colors. OS-65D with Microsoft BASIC, assembler and debugger with all manuals and lots of software. Over $3500; asking $2500 in Canadian funds. Daniel Filteau, 1471 Bourgeoys, Longueuil, Quebec J4M 1Z5, Canada, (514) 468-3820.

FOR SALE: Tektronix 4054 graphics terminal. 300 hours total time used. Less than 50 hours on CRT tube. Options: #01—Data Communication Interface; #24—64K-bytes total memory; #30—Dynamic Graphics. Also, Trans-Era A/D converter unit and Trans-Era BCD-Binary I/O unit. Walt Hedges, 4635 West Euclid, Laveen, AZ 85339, (602) 237-4080.

WANTED: S-100 boards. Three Compupro RAM 20 32K static: $125 each. Two Tarbell DD controllers with CP/M 2.2: $200 each. Compupro I/O: $100. Compupro CPU-Z: $200. All boards perfect with manuals. Jim Blair, (318) 367-8455.

WANTED: Student would appreciate an unwanted, new, or used copy of Beneath Apple DOS (Worth & Lechner, for Apple DOS 3.3) and/or Bag of Tricks. Willing to pay, or trade software or a copy of *6502 Assembly Language Programming* (L. Leventhal) in new condition. Darryl Dueck, 59 Pinecrest Bay, Winnipeg, Manitoba R2G 1W2, Canada, (204) 668-5176.

WANTED: Used Olivetti Praxis 30 electronic typewriter. Long Kha, 7322 Mesa College Dr., Apt. 18, San Diego, CA 92111, (619) 277-4277.

WANTED: TRS-80 software to swap. Also, need help in repairing a TRS-80 logic board Model I G version; need two ROMs set. I have some TRS-80 upgrade plans for trade. Looking for 80-column TRS-80 Model I upgrade plans. Send SASE for replies. Tim Cochrane, POB 176, Industry, PA 15052.

FOR SALE: Apple software: Wizard and the Princess for $18 or best offer and Ultima for $25 or best offer. Both in original packing. Also, will buy or borrow used adventures and games. Darrin Rothe, 310 North Main, Deer Park, WI 54007, (715) 269-5313 after 5 p.m. and weekends.

WANTED: Percom Doubler A (the one discarded when you upgraded to Doubler II) for TRS-80 Model I; Level II ROM chips for newer Alps keyboard (the set that mounts directly on main board), and aircraft navigation software on disk. H. Sherwin, 609 South Main St., Clearfield, UT 84015, (801) 773-8005.

FOR SALE: Persci 270 dual 8-inch SS/SD floppy-disk drive and power supply. Very fast and factory maintained: $395. Alan Westhagen, 6814-20th NE, Seattle, WA 98115, (206) 524-7335.

WANTED: Anyone who wants to exchange programs & software for a Processor Tech SOL-20. T. and N. Eliasson, Gosgatan 15 S-72348 Vasteras, Sweden.

WANTED: VIC-20 books, tapes, cartridges, or other new or used equipment. Please send list when corresponding. Bart Kreuser, 1695 Biemeret, Green Bay, WI 54304.

FOR SALE: Two Calcomp #142 SSDD 8-inch drives, one Calcomp #142M SSDD 8-inch drive; both need repair. Also, Tarbel SD FDC, Calcomp jumpered, Shugart adaptor; IA Z80 2-MHz CPU with CP/M boot PROM; Cromemco Z80 monitor PROM; 16K Godbout Econoram IV static RAM; 16K WMC MEM-2 static RAM; and four 8K Godbout Econoram II static RAM. Complete documentation on each item. Make an offer. Dave Raibert, (201) 444-4600 and 529-3595.

WANTED: Young robotics A.I. experimenter would like contact with others with same interests. Peter J. Skelley, 16121 59th Ave. SE, Snohomish, WA 98290.

FOR SALE: Altos 16-bit multiuser computer with hard disk. The system has Horizon WP, *Accounting, and* Multiplan running under the Xenix operating system. New: $16,700, asking $7200. Mike Hughes, 1245 West Huntington Dr. #207, Arcadia, CA 91006, (213) 287-7385.

Unclassified Ads

FOR SALE: Fortune 32:16 computer with hard disk, Unix operating system, WP, Multiplan, and accounting software. Asking half of what the system costs. Russ Sharer, POB 3535, Arcadia, CA 91006, (213) 445-8720.

WANTED: To trade a one-month-old Radio Shack TRS-80 (MC10) with some money, for a used Jupiter Ace with some software and documentation. William V. Petro Jr., 30047 Regent, Wickliffe, OH 44092, (216) 944-5903.

FOR SALE: Radio Shack TRS-80 Model I with Level II BASIC. Comes with functioning keyboard, monitor, cassette recorder, several games, and complete documentation. Will trade for IBM PC software/hardware or best offer. Michael Beauchamp, 313 Old Post Rd., Waterloo, Ontario N2L 5P3, Canada, (519) 885-0891.

WANTED: People who are interested in or use the Logo language. I would like to exchange programs, ideas, and information. Keith Robison, 113 Morris Rd., Exton, PA 19341.

WANTED: TDL Assembler, Chess, and Statistics software in source listing and on 5¼-inch disk for Osborne 1 in single density. Will give you other software in exchange. Hermann Locarek, Fuggerstr. 4, 8901 Stadtbergen, West Germany.

FOR SALE: Xerox 820 computer with two 5¼-inch DS/DD drives or two 8-inch SS/DD drives. Also, Xerox/Diablo 630 letter-quality printer. James Long, Rt. 3 No. 6 Autumnwood, Holts Summit, MO 65043, (314) 896-5989 after 7 p.m.

FOR SALE: Back issues of BYTE, vol. 1, no. 1 (1975) through 1982, complete except for vol. 1, no. 2, 3, 5, and 9. Mint condition, $250 includes U.S. shipment. Bill Schweber, POB 543, Sharon, MA 02067.

FOR SALE: Netronics Explorer-85 system. Complete with keyboard, 64K memory, two 8-inch disk drives, and CP/M. All in perfect working order; will sell for best offer. Larry Katz, 854 North Krome Ave., Homestead, FL 33030, (305) 248-7561 days.

FOR SALE: TRS-80 Model I 48K, RS-232C, modem, DEC printer, software, manuals: $975. CCTV Security System with two cameras, monitor, more: $500. 3M 257 desk copier: $175. Also, TRS-80 Model 16 256K, two drives, real-time clock, Xenix/Unix software, modem, printer, terminal, hard disk, more: $7950. Jim Thomas, POB R, Pine Lake, GA 30072, (404) 498-1401.

FOR SALE: BYTE January 1981 through December 1982 (24 issues) and Microcomputing January 1977 through October 1982 (70 issues): $170, prepaid. Will consider VIC-20, TI 99, etc. as partial trade. Paul Schmidtke, 4308 East Little Creek Rd., Tucson, AZ 85712, (602) 326-0442.

FOR SALE: BYTE, 7/76 thru 10/76 and 1/77 thru 12/82, missing one issue: $200. Interface Age, 1/77 thru 12/82, missing 7/78: $150. Kilobaud, 10/77 thru 12/82, missing 3 issues: $125. Creative Computing, 3/77 thru 6/81, missing two issues: $100. Personal Computing, 7/78 thru 12/81, missing 1 issue: $75. All plus shipping. Also dr. dobbs, etc. George Lang, 306 East 96th St., NY, NY 10128, (212) 348-3610.

WANTED: Texas Instruments Model 1 computer. D. Jones, POB 778, Daly City, CA 94017, (415) 877-8676.

FOR SALE: Hardware maintenance and service library package for IBM Personal Computer XT: #6936809, never opened, sealed: US$80. I pay shipping. Luis Baez, 7922 East Drive, North Bay Village, FL 33141, (305) 756-5687 evenings.

WANTED: Byte Nybble document #112 ("An M6800 LISP Interpreter," 1979); MIT Artificial Intelligence Lab "HakMem" Memo #239 (on Collatz' problem, 1972); and a textbook, "Computer Approaches to Mathematical Problems" by J. Nievergelt (Prentice-Hall, 1974). Will pay copy costs and postage or *will buy your* original at your price. Barry Knapp, 4695 Osage Dr., Boulder, CO 80303, (303) 494-8390.

FOR SALE: 2708 EPROMs. 200 EPROMs were removed when equipment was upgraded to 2716. All were working when removed; perfect for the hobbyist. 1 to 25: $1.25 each; 25 or more at $1 each. Rich Matthews, POB 80685, Baton Rouge, LA 70898, (504) 291-0832 evenings and weekends.

FOR SALE: Codata CTW 300/20/f8 8-user Unix computer. 20-megabyte fixed disk, 386K floppy, 256K RAM, C, Pascal, FORTRAN 77, excellent condition: $11,950. Tom Cole, 1207 Cederwood Dr., Joliet, IL 60435, (815) 729-0300.

WANTED: Atari 810 disk drives, used but in good working order. Also, 1200-bps modem with software for Atari 800, 80-column board, 48K RAM plug-in board, and business-oriented software. Offers of game programs given consideration. Stephen A. Risik, 10224 Windsor View Dr., Potomac, MD 20854.

WANTED: Technical and service information for a G.E. TN-1200 impact (chain) printer. Also, nonworking printer for parts. Russel Hill, c/o Industrial Counseling Services, POB 278, Ashland, OR 97520, (503) 488-0220.

BOMB
BYTE's Ongoing Monitor Box

Article #	Page	Article	Author(s)
1	30	The Apple Macintosh Computer	Williams
2	58	An Interview: The Macintosh Design Team	Lemmons
3	84	Apple Announces the Lisa 2	Williams
4	88	Build the Circuit Cellar Term-Mite ST Smart Terminal, Part 2: Programming and Use	Ciarcia
5	113	User's Column: Chaos Manor Gets Its Long-Awaited IBM PC	Pournelle
6	147	BYTE West Coast: A Business Computer, A Business Program, and More on Voice Recognition	Shapiro
7	160	Don't Bench Me In	Houston
8	168	Beyond MIPS: Performance Is Not Quality	Carroll, Rosson
9	175	Software Performance Evaluation	Boyle
10	193	The Art of Benchmarking Printers	Mello-Grand
11	218	Benchmarking FORTRAN Compilers	Tetewsky
12	227	Benchmark Confessions	Marvit, Nair
13	235	The Word-Processing Maze	Lewis
14	243	Evaluating Word-Processing Programs	Naiman
15	252	ProDOS	Moore
16	267	Knowledgeman	Walker
17	278	The IBM CS-9000 Lab Computer	Clune
18	292	The Rixon R212A Intelligent Modem	Weger
19	303	Savvy	Callamaras
20	308	The Micro-Sci Gameport III for the Apple III	Purpura, Purpura
21	310	The Videx Ultraterm	Callamaras
22	318	Apple Disk Emulators: Axlon, Legend, Pion, and Synetix	Gilbert
23	331	IBM/Apple Communication	Jones
24	342	A Low-Cost, Low Write-Voltage EEPROM	Blagg
25	346	Foot^Control	Pfister
26	349	Inside a Compiler: Notes on Optimization and Code Generation	Christian
27	370	Writing Device Drivers for MS-DOS 2.0 Using Tandon TM100-4 Drives	Roskos
28	383	Deciphering Word Games	Worley
29	388	Five Original Graphics	Sussman, Sussman
30	395	Bubbles on the S-100 Bus, Part 2: The Software	Wheeler
31	416	Calculating Overhead Costs by Computer	Hunter

BOMB Cites Chaos Manor

Jerry Pournelle's User's Column, "The Latest from Chaos Manor," won top spot in the November BOMB. Dr. Pournelle wins $100. The five authors of "Technical Aspects of IBM PC Compatibility," Charlie Montague, Dave Howse, Bob Mikkelsen, Don Rein, and Dick Mathews, will divvy up the $50 prize for second place. "Concurrent CP/M" by Joe Guzaitis grabbed third place. Lawrence J. Curran and Richard S. Shuford's interview with "IBM's Estridge" was a close fourth. And Bobbi Bullard's "Comparing the IBM PC and the TI PC" placed fifth. Heartiest congratulations to these authors.

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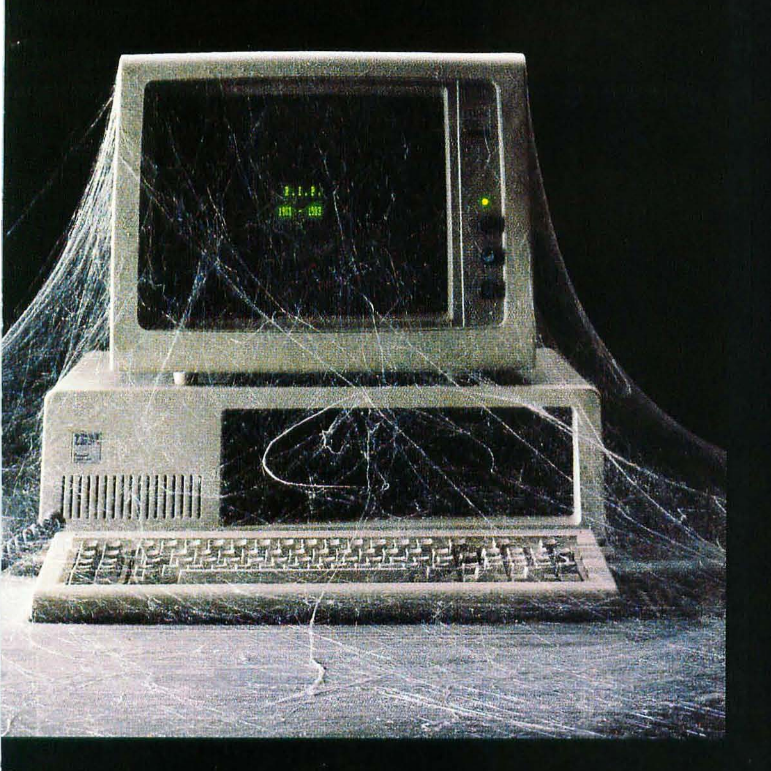
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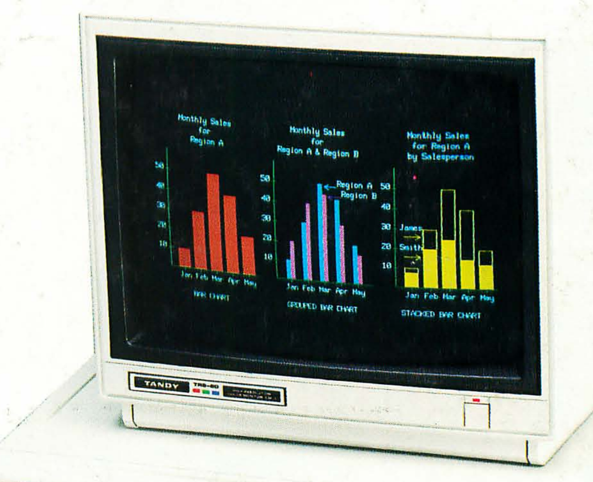
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Display/Printer Adapter	Included	$335
128K RAM (Total)	Included	$165
RS-232	Included	$120
MS-DOS 2.0	Included	$60
Total Cost*	$2999	$3658
Feature Description	**Tandy 2000**	**IBM Personal Computer**
Internal Memory	128K Standard	64K Standard
Disk Capacity Per Drive	720K	160K or 320K (optional)
Microprocessor Clock Speed	8 MHz	4.7 MHz
True 16-Bit Microprocessor	Yes (80186) 16-bit/16-bit data path	No (8088) 16-bit/8-bit data path
User-Available Expansion Slots*	4	2
Graphics Options		
Color Resolution	640 × 400	320 × 200
Number of Colors	8	4
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